



US009130210B2

(12) **United States Patent**  
**Hamada et al.**

(10) **Patent No.:** **US 9,130,210 B2**  
(45) **Date of Patent:** **Sep. 8, 2015**

(54) **BATTERY PACK**

(71) Applicant: **NISSAN MOTOR CO., LTD.**,  
Yokohama-shi, Kanagawa-ku (JP)

(72) Inventors: **Karuki Hamada**, Yokohama (JP);  
**Tadashi Shoji**, Yokohama (JP); **Yukari**  
**Tadokoro**, Sagamihara (JP); **Taichi**  
**Oyama**, Tokyo (JP)

(73) Assignee: **NISSAN MOTOR CO., LTD.**,  
Yokohama-shi (JP)

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 134 days.

(21) Appl. No.: **14/077,975**

(22) Filed: **Nov. 12, 2013**

(65) **Prior Publication Data**

US 2014/0065458 A1 Mar. 6, 2014

**Related U.S. Application Data**

(62) Division of application No. 10/202,011, filed as  
application No. PCT/JP2010/057216 on Apr. 23,  
2010, now Pat. No. 8,592,068.

(30) **Foreign Application Priority Data**

Apr. 24, 2009 (JP) ..... 2009-106856  
Apr. 24, 2009 (JP) ..... 2009-106895

(51) **Int. Cl.**  
**H01M 2/10** (2006.01)  
**H01M 2/02** (2006.01)  
**H01M 6/42** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01M 2/1077** (2013.01); **H01M 6/42**  
(2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

3,623,917 A	11/1971	Chassoux
4,065,603 A	12/1977	Coibion
4,113,926 A	9/1978	McBrien
5,747,186 A	5/1998	Morishita et al.
5,766,801 A	6/1998	Inoue et al.
6,197,446 B1	3/2001	Fukuda et al.

(Continued)

**FOREIGN PATENT DOCUMENTS**

JP	08-264170 A	10/1996
JP	09-120808 A	5/1997
JP	2001-345082 A	12/2001

(Continued)

**OTHER PUBLICATIONS**

Supplementary European Search Report dated Feb. 26, 2014 (6 pgs.).

(Continued)

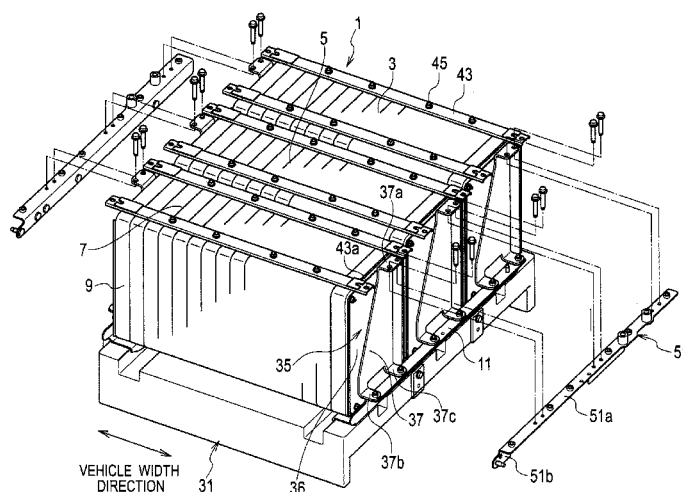
*Primary Examiner* — Cynthia K Walls

(74) *Attorney, Agent, or Firm* — Foley & Lardner LLP

(57) **ABSTRACT**

A battery pack (1) includes: paired supporting members (35); a battery module (3, 5, 7) disposed between the supporting members (35); and a stack member (43) supporting the battery module (3, 5, 7) by linking the supporting members to each other. An extending portion (43a) protruding from the battery module (3, 5, 7) is formed by extending an end portion of the stack member (43). Accessories (12) are attached to a side surface on a side where the extending portion (43a) of the stack member (43) is disposed, the side surface being one of side surfaces of the battery pack which are provided with the paired supporting members (35).

**4 Claims, 21 Drawing Sheets**



(56)

References Cited

U.S. PATENT DOCUMENTS

7,479,758 B2 1/2009 Moon  
2007/0141459 A1 6/2007 Goto et al.

FOREIGN PATENT DOCUMENTS

JP 2004-311290 A 11/2004  
JP 2006-120489 A 5/2006

JP 2007-165164 A 6/2007  
JP 2008-186725 A 8/2008  
RU 76169 U1 9/2008  
RU 2 338 302 C1 11/2008  
SU 1762343 A1 9/1992

OTHER PUBLICATIONS

Japanese Office Action and English Language Translation dated Jul. 9, 2013 (3 pages).

FIG. 1

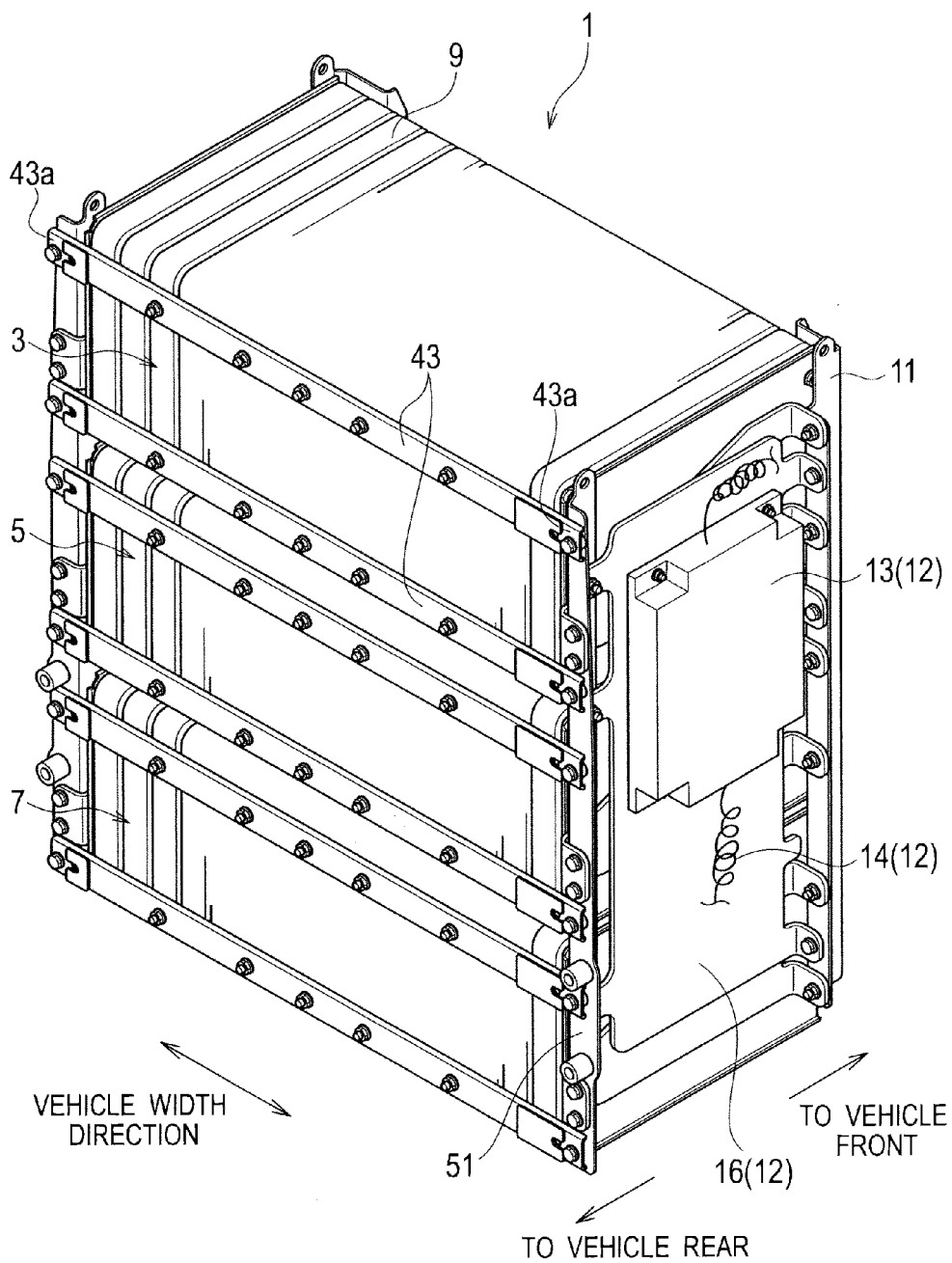


FIG. 2

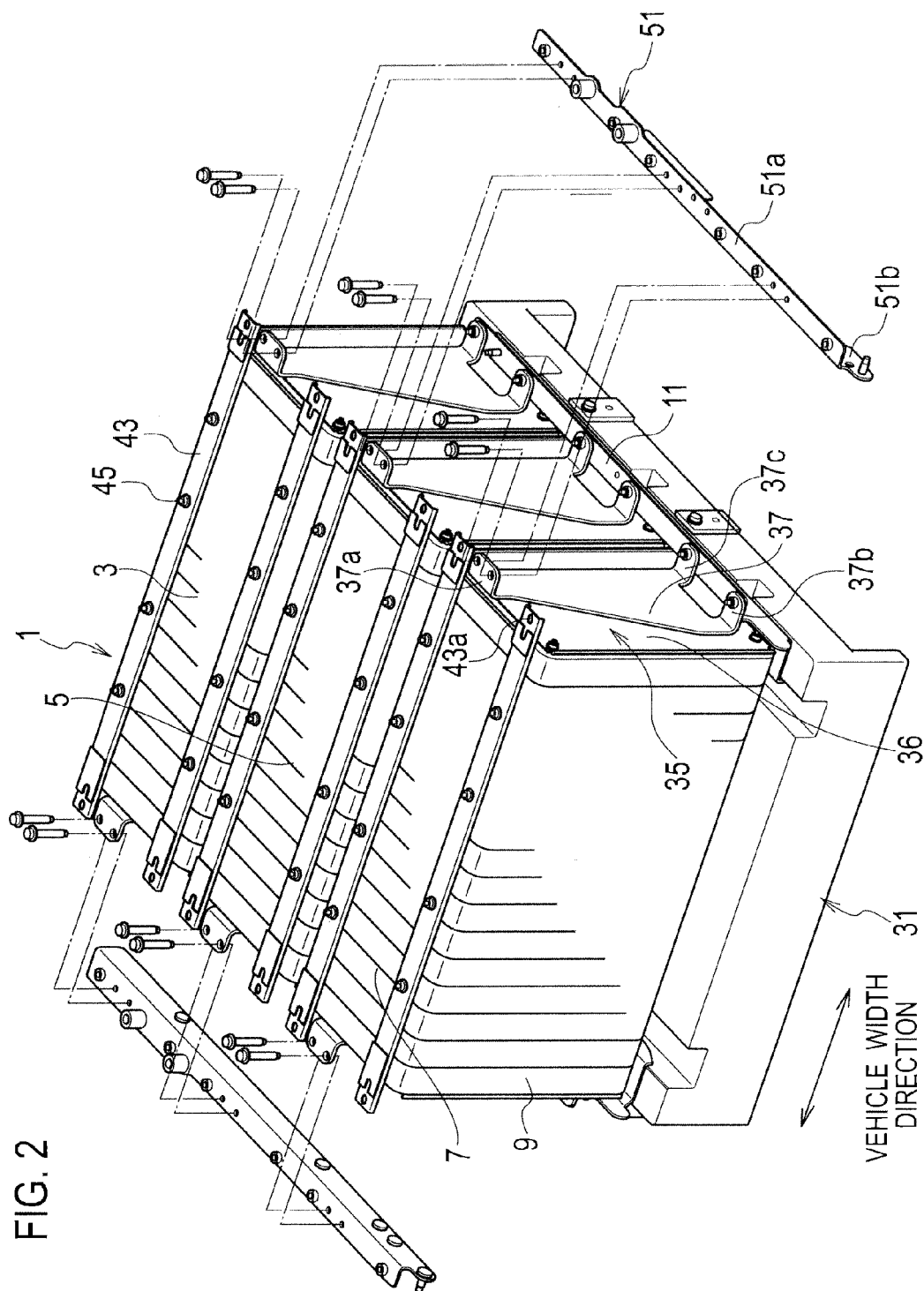


FIG. 3

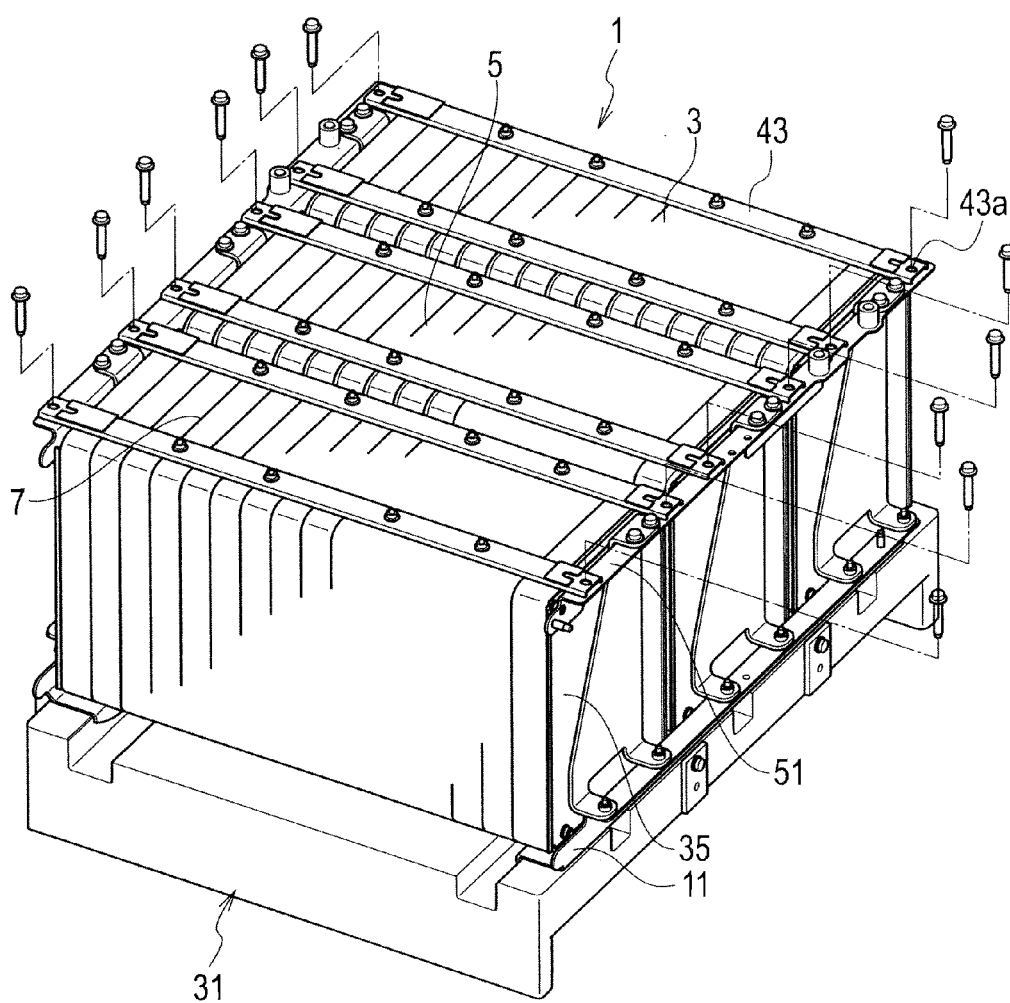


FIG. 4

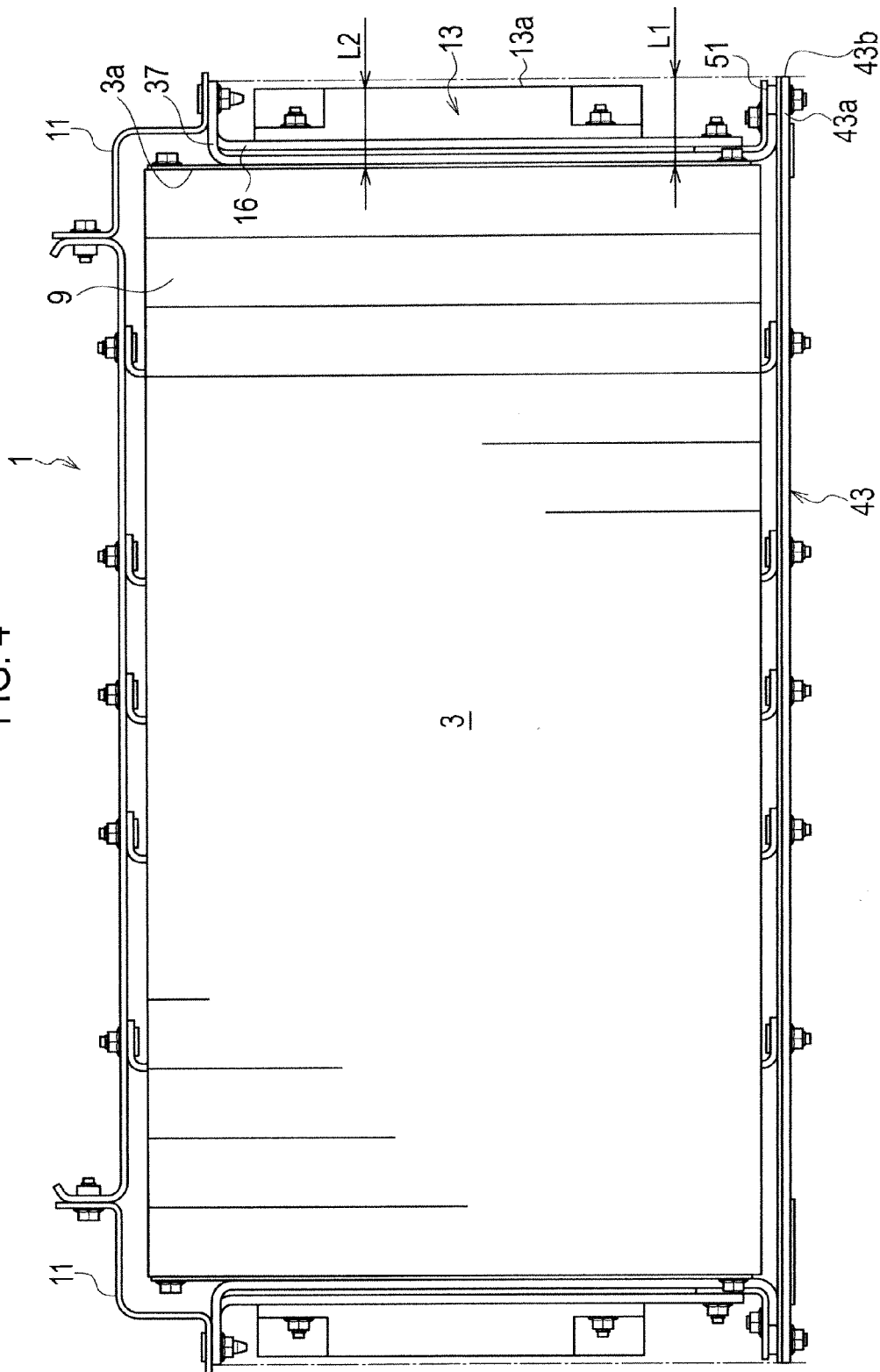


FIG. 5

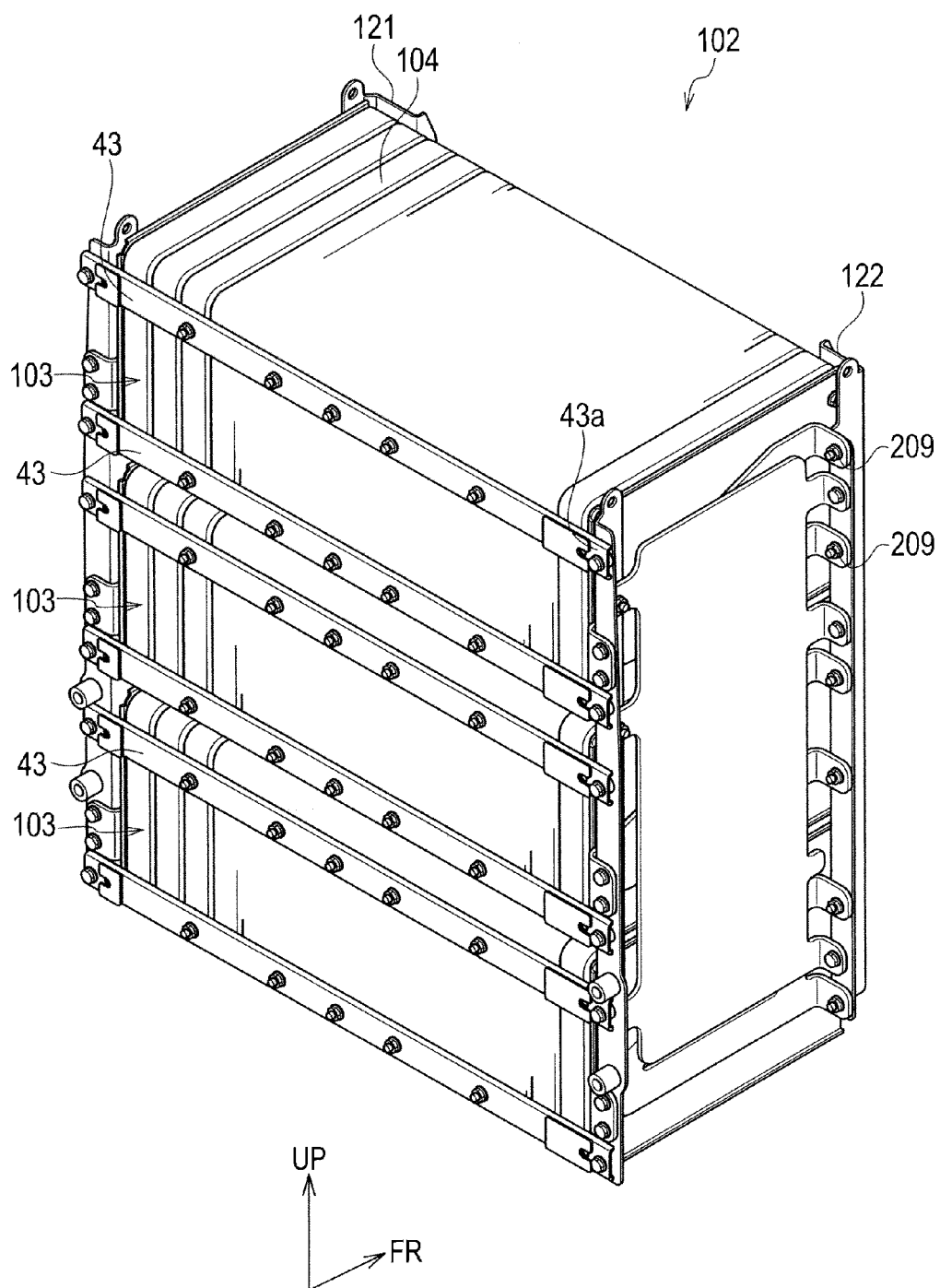


FIG. 6

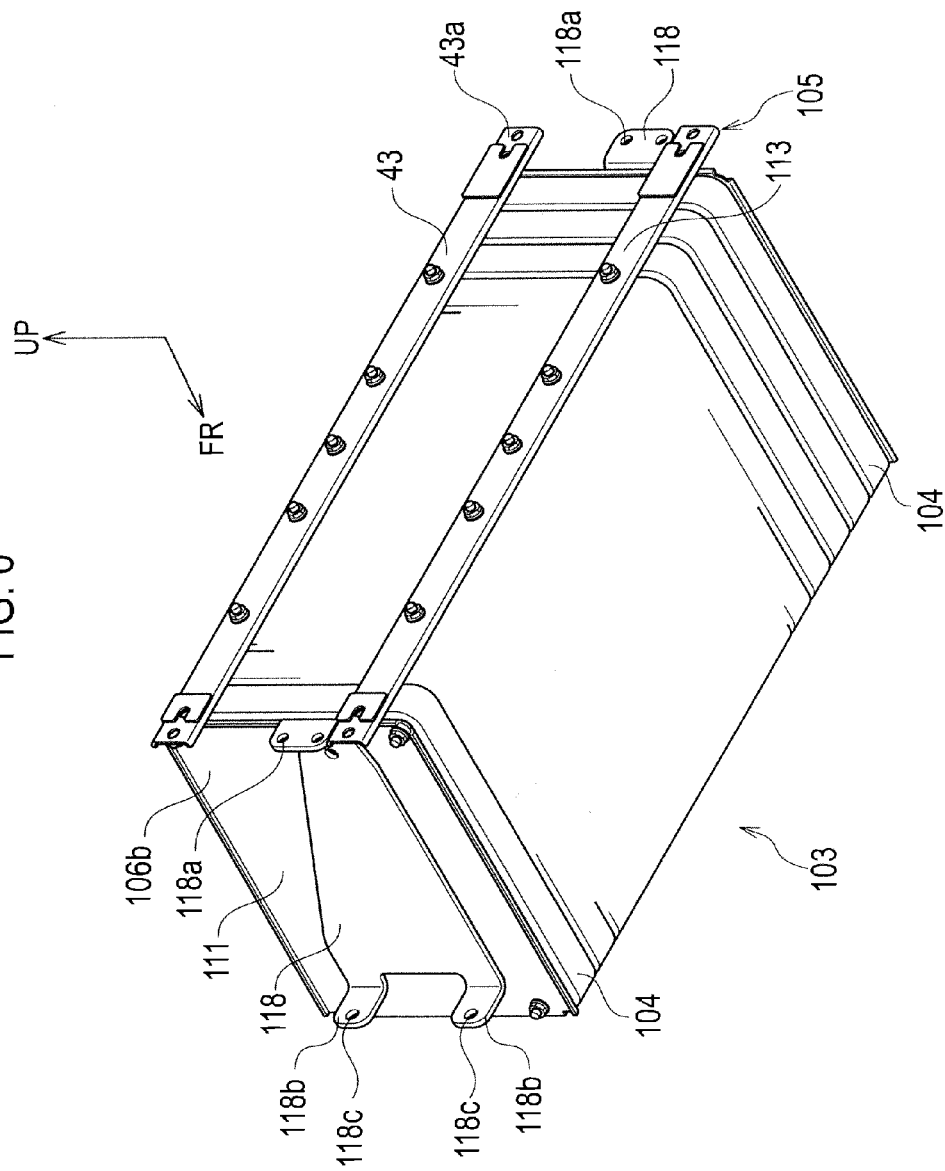


FIG. 7

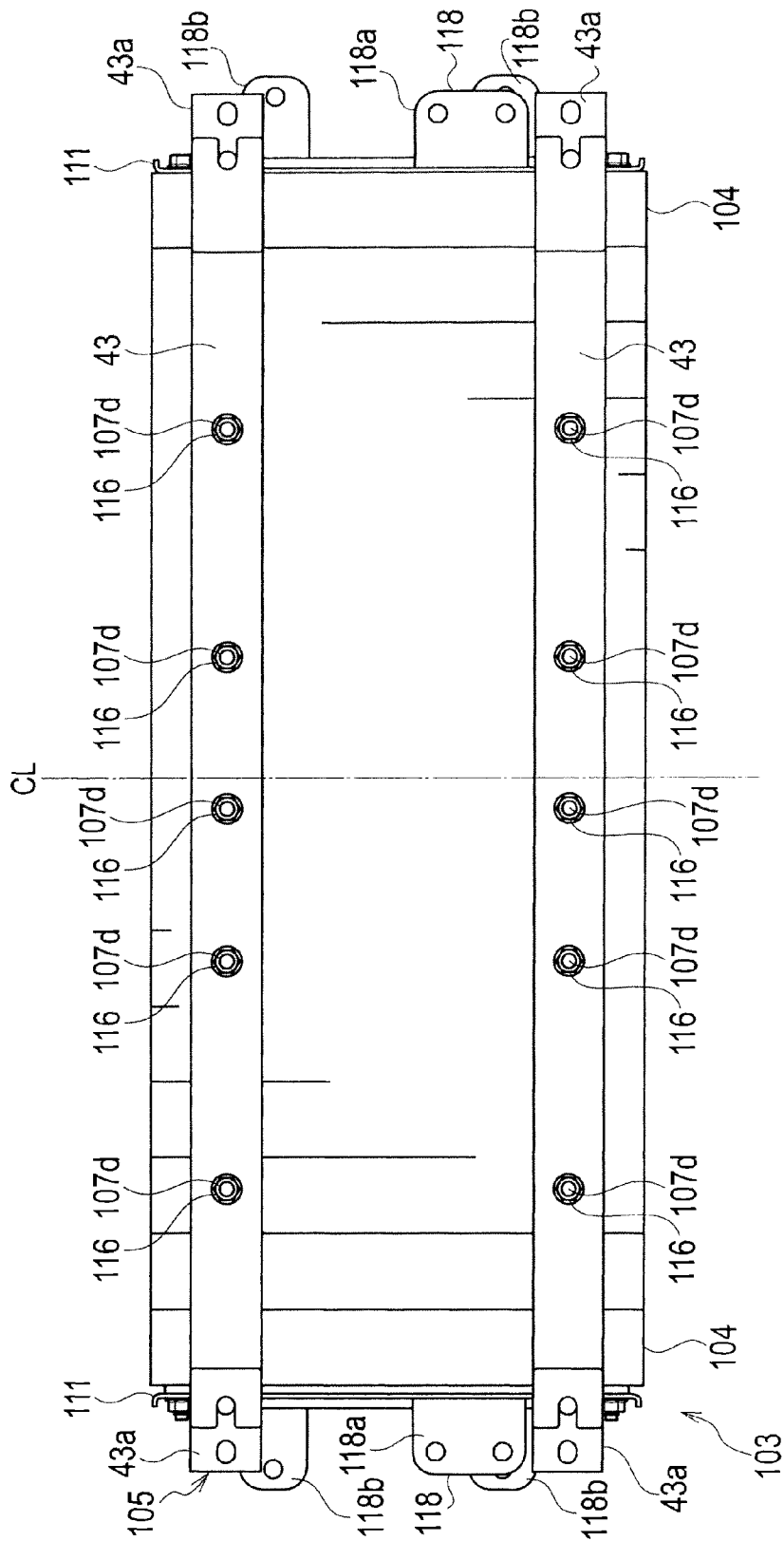


FIG. 8

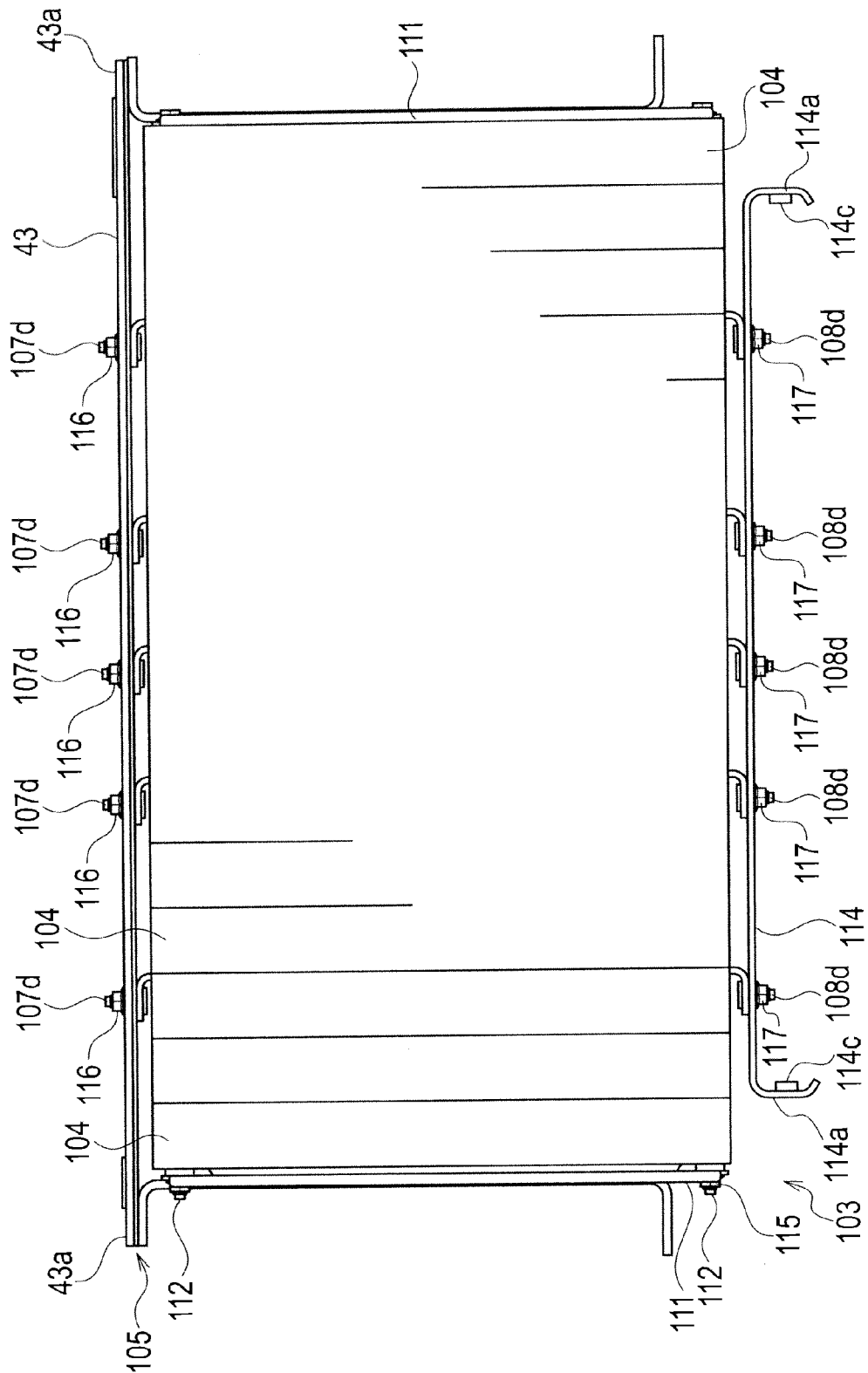


FIG. 9

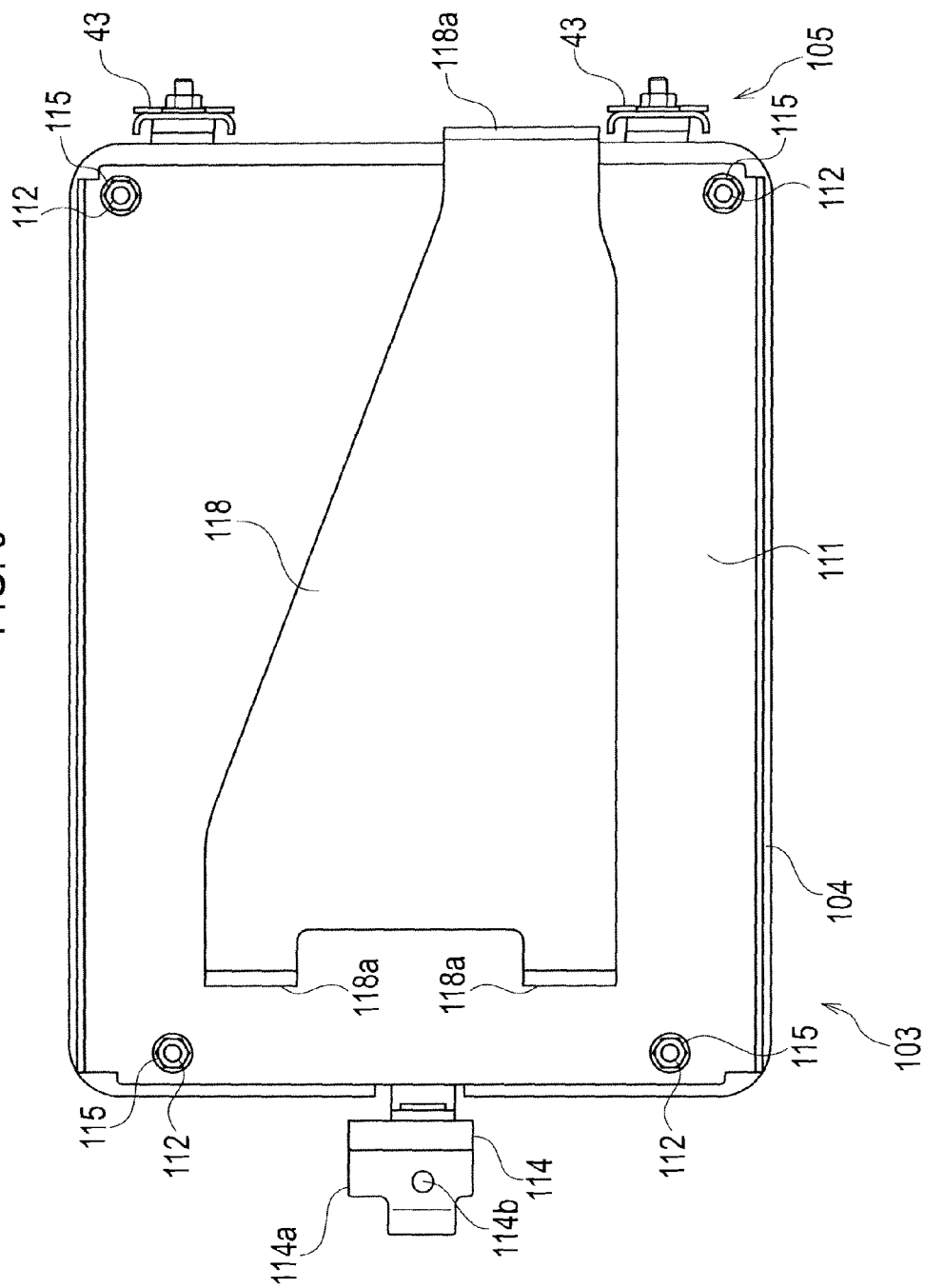


FIG. 10

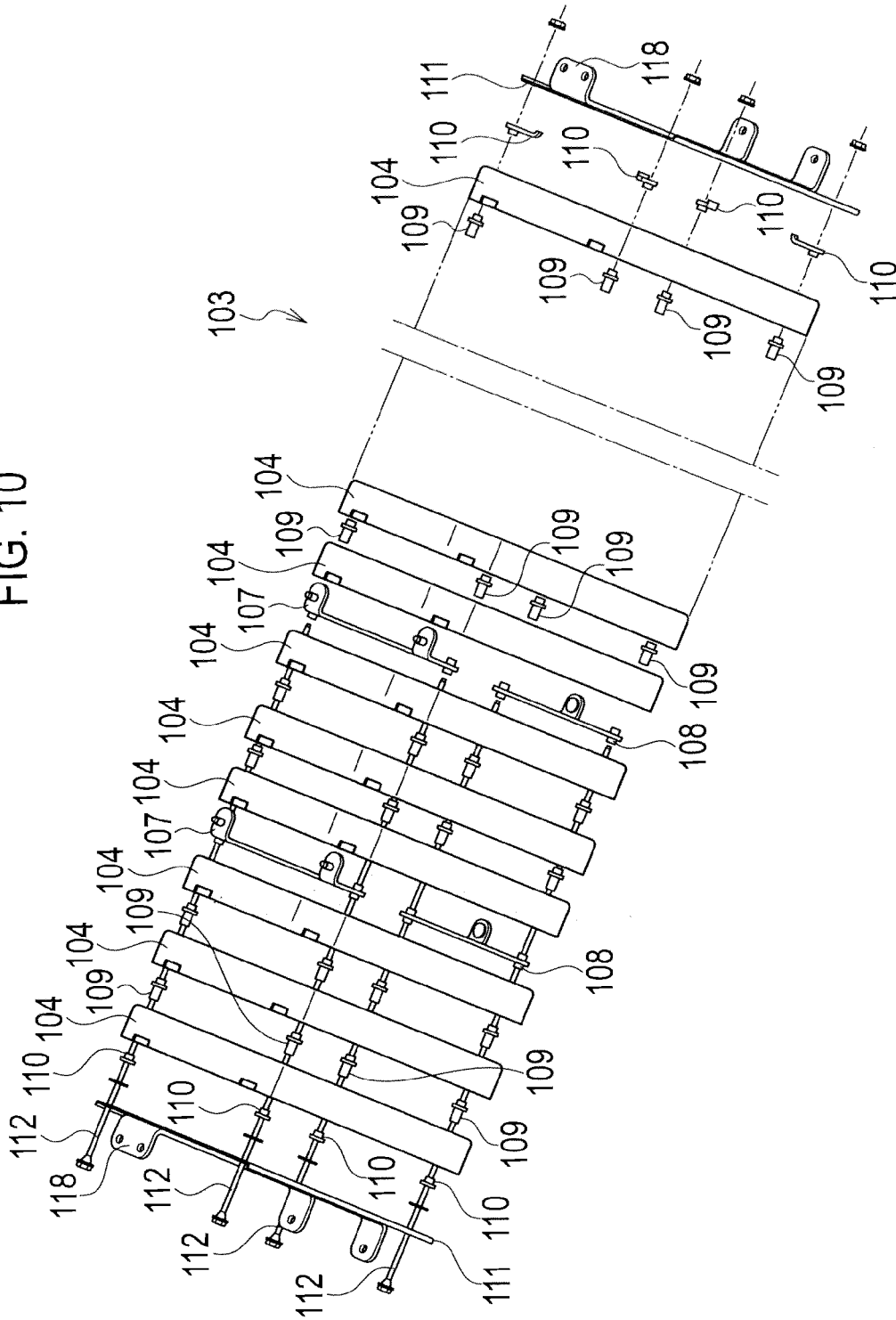


FIG. 11

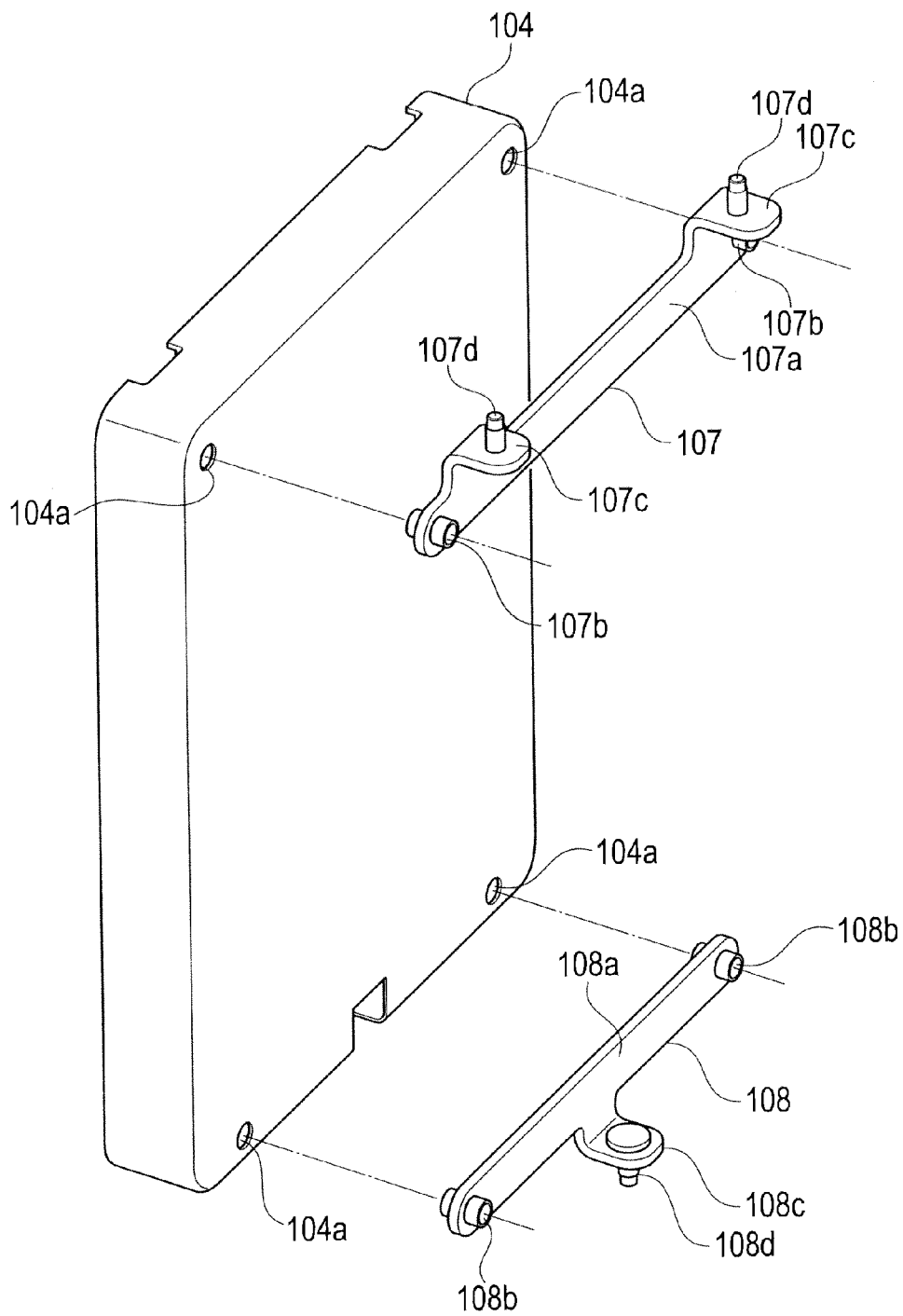


FIG. 12

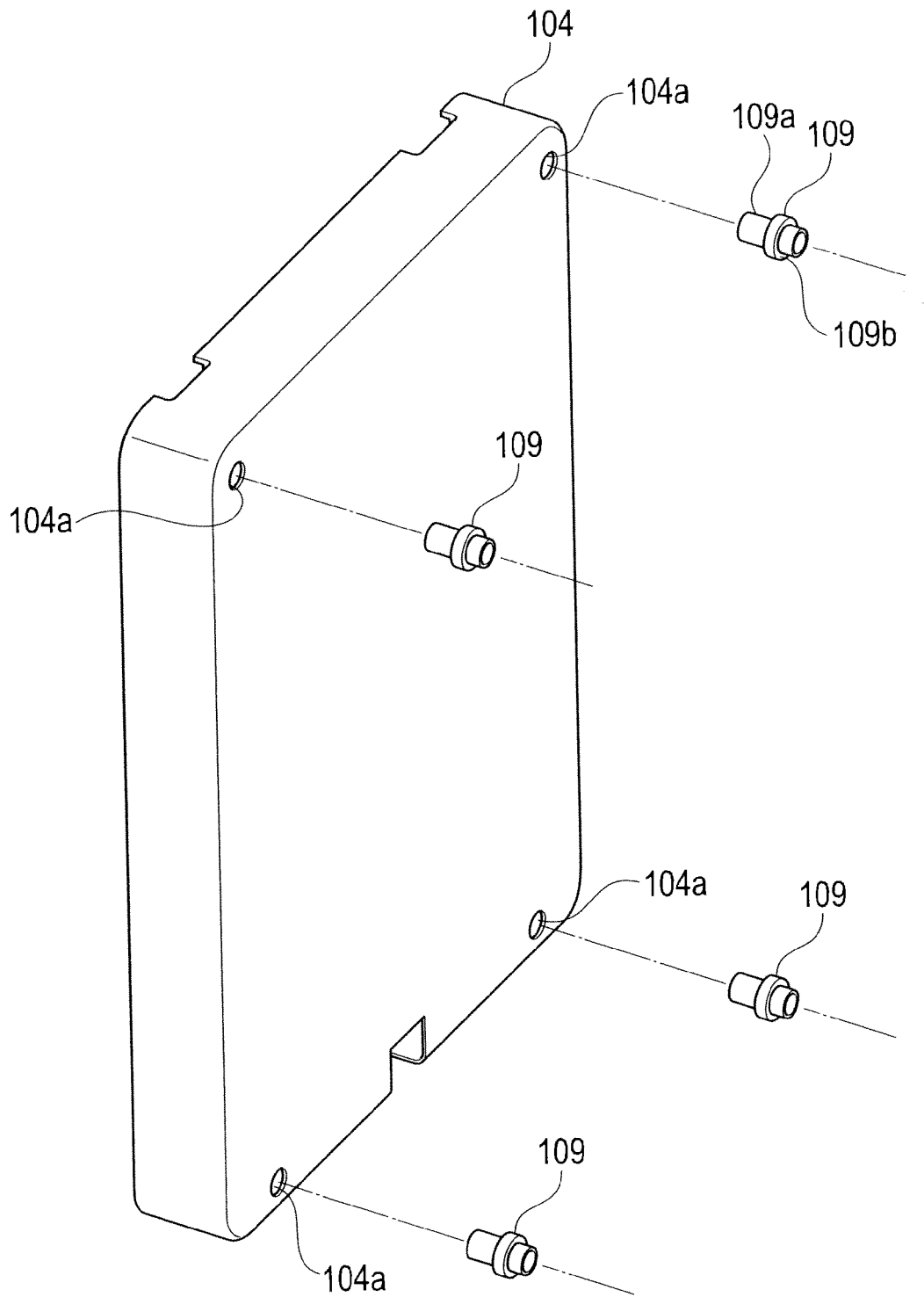


FIG. 13

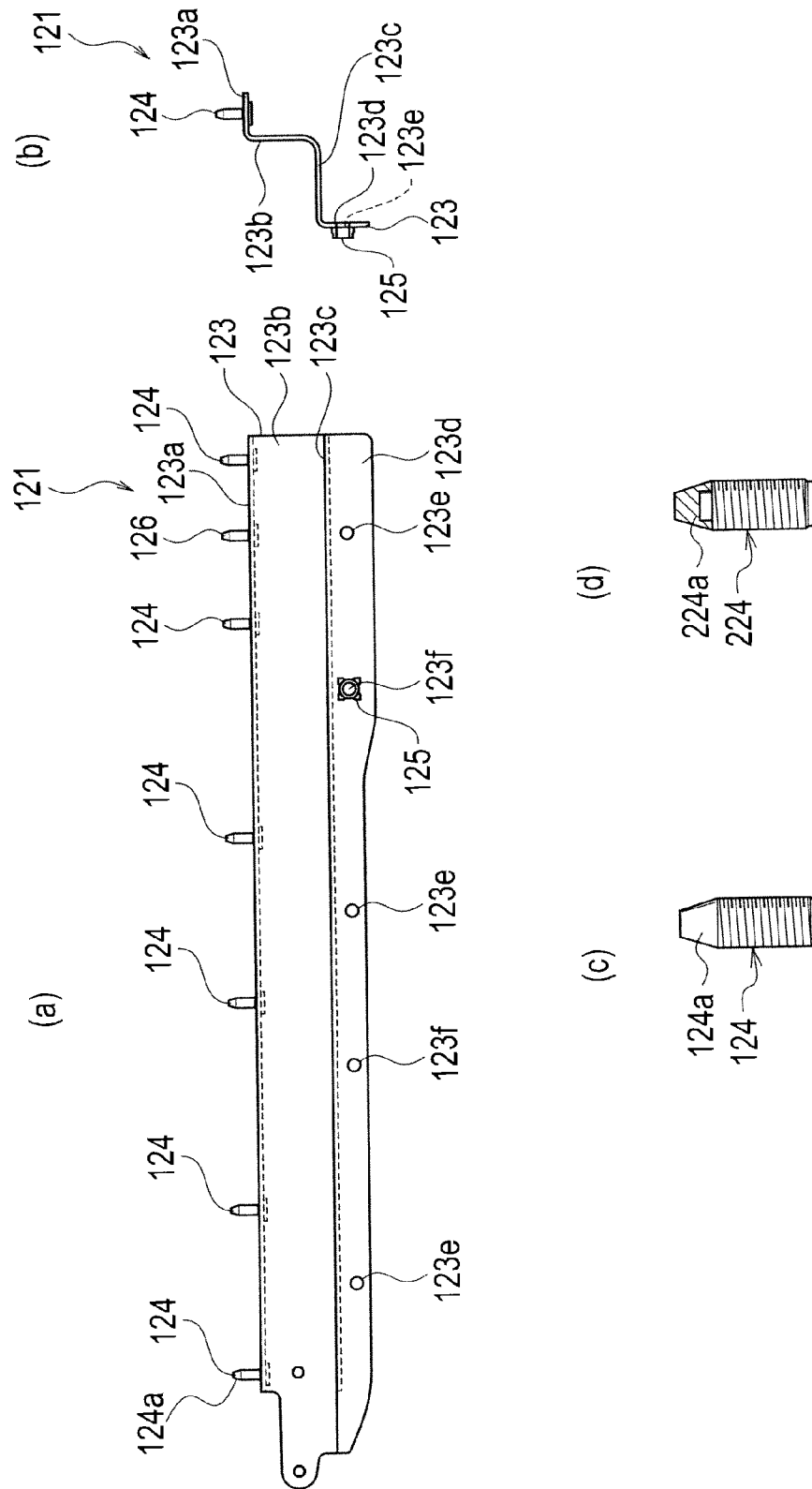


FIG. 14

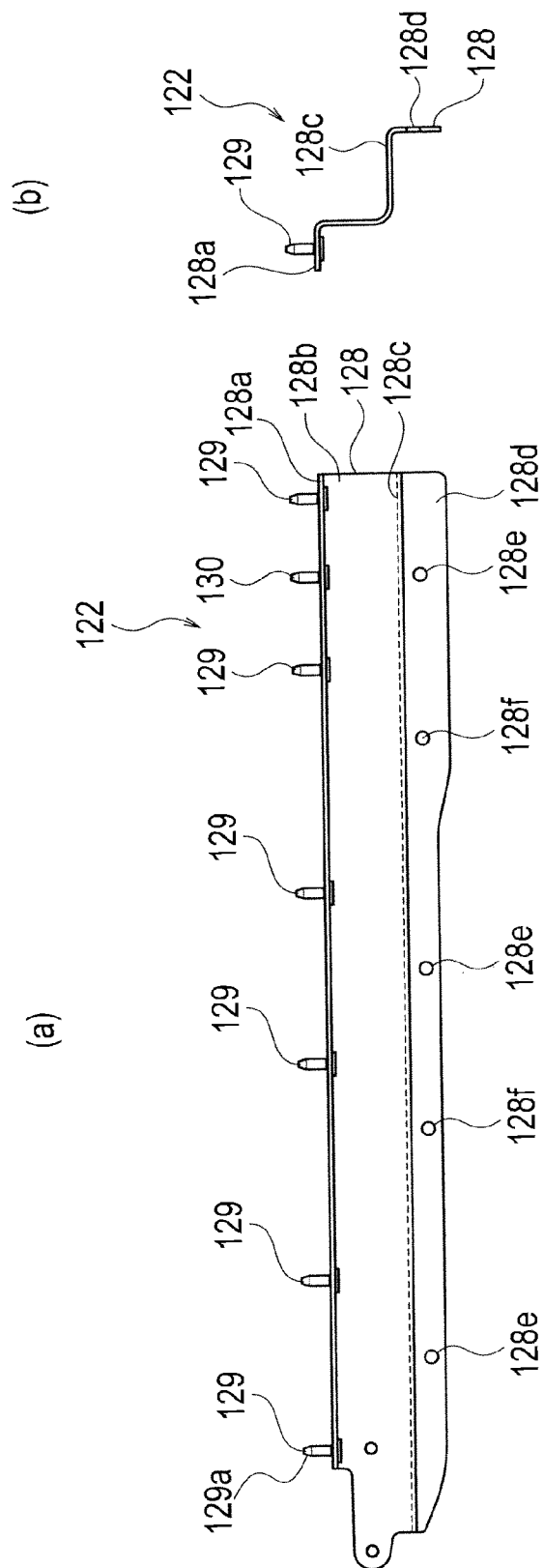
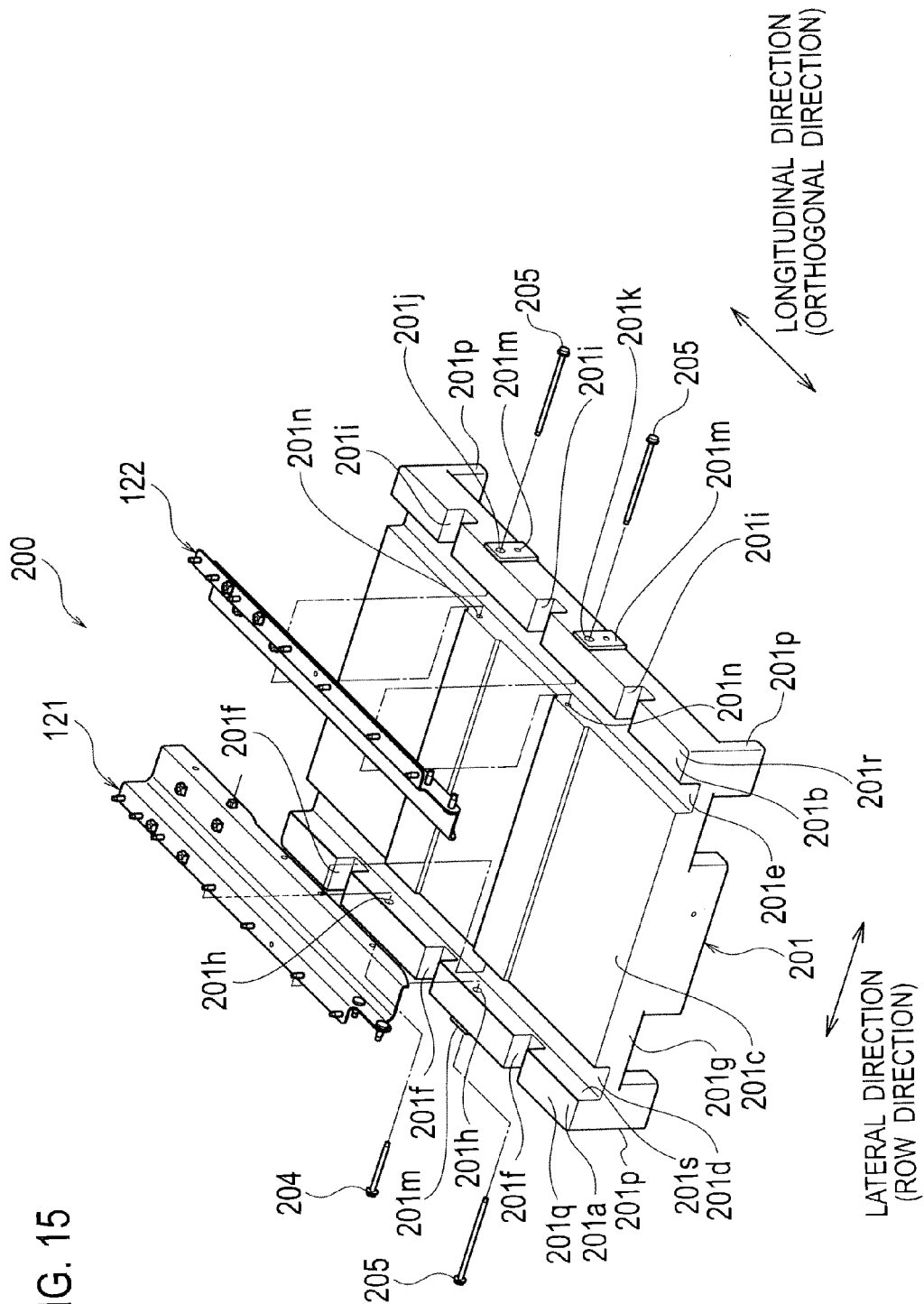


FIG. 15



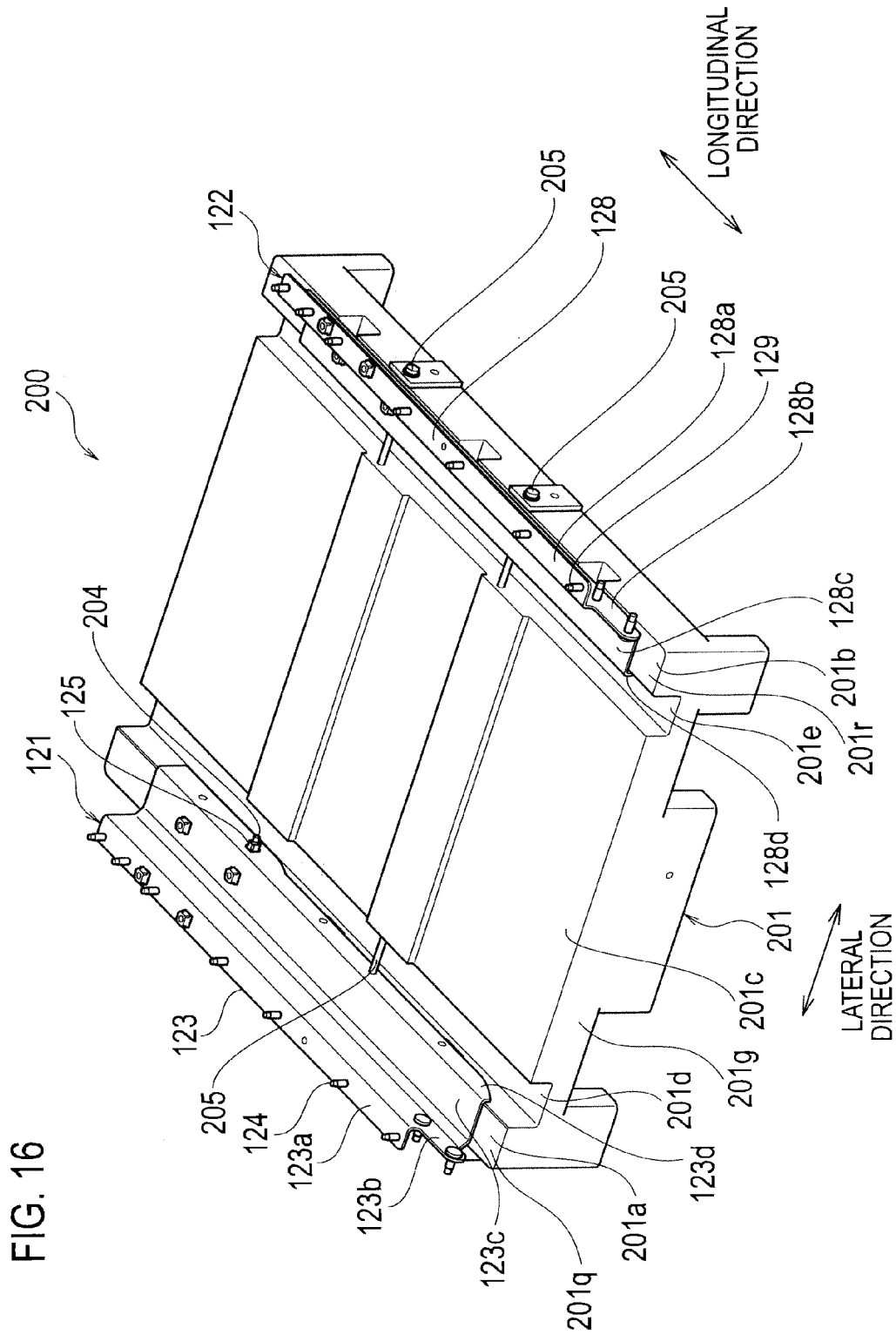
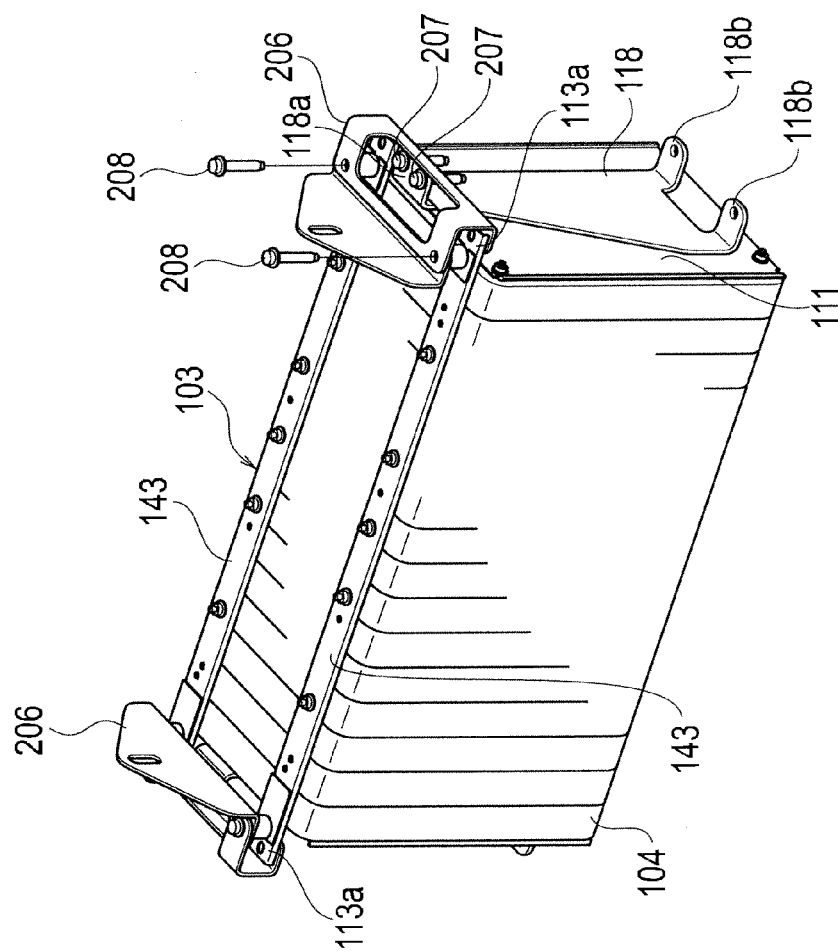
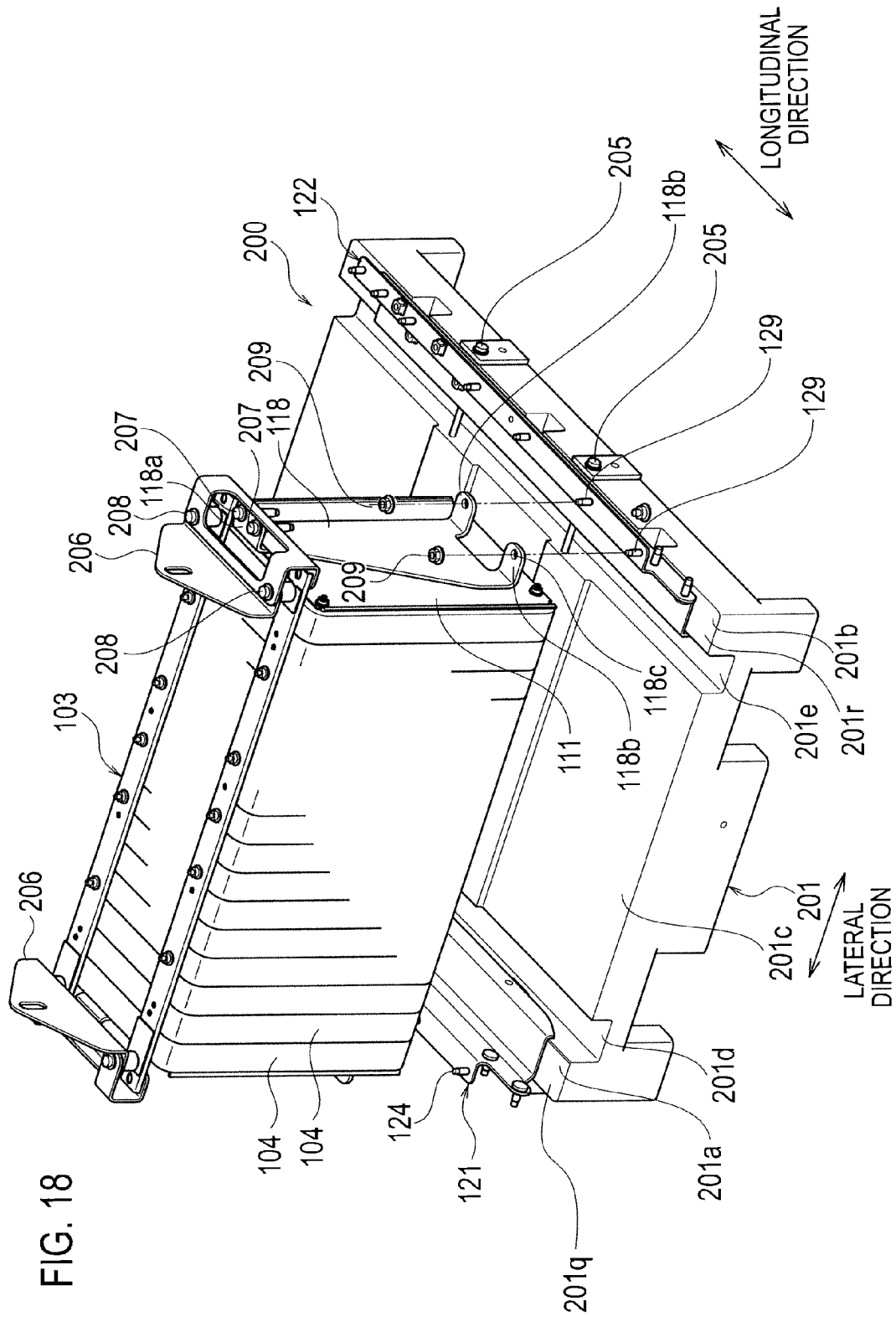
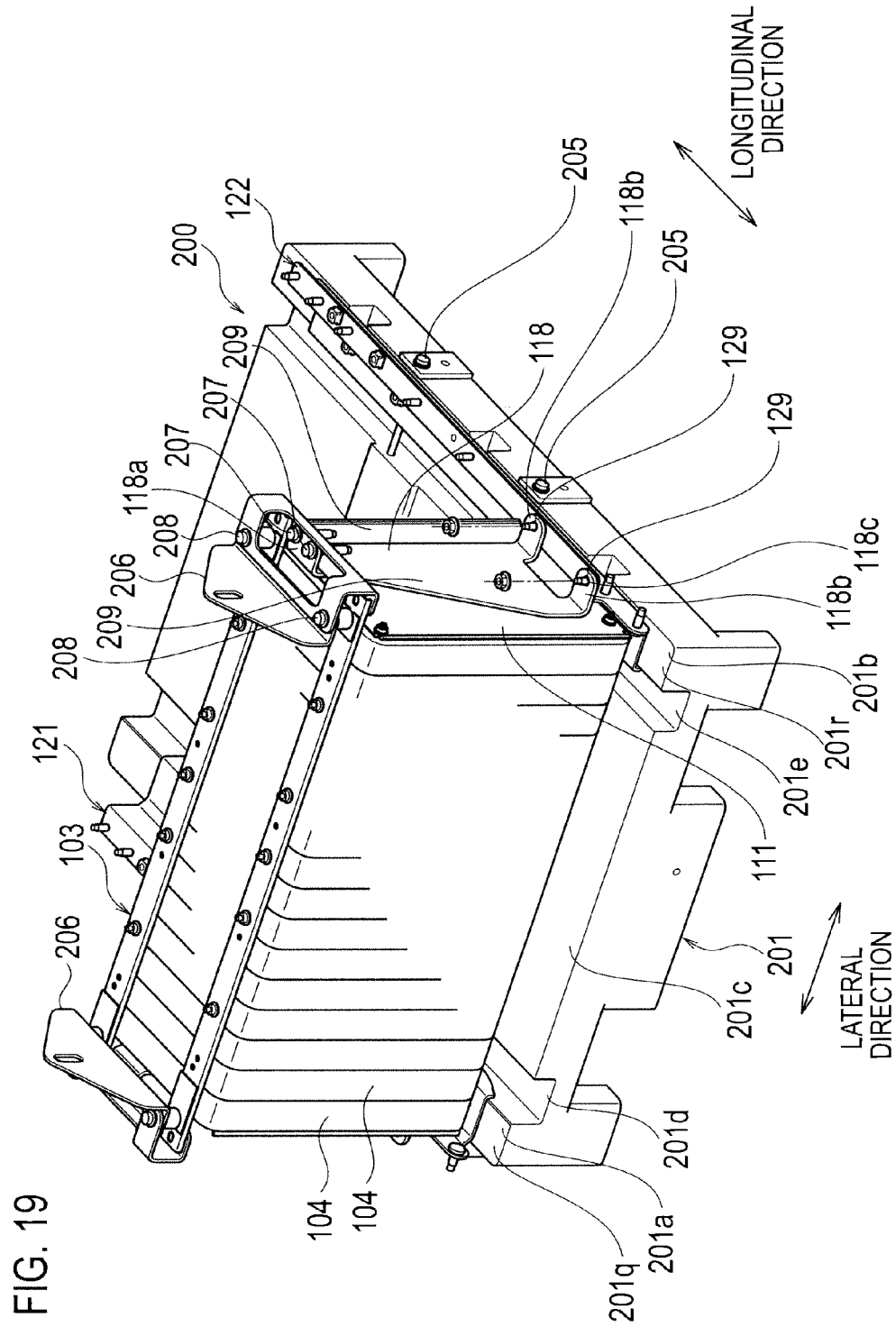


FIG. 17







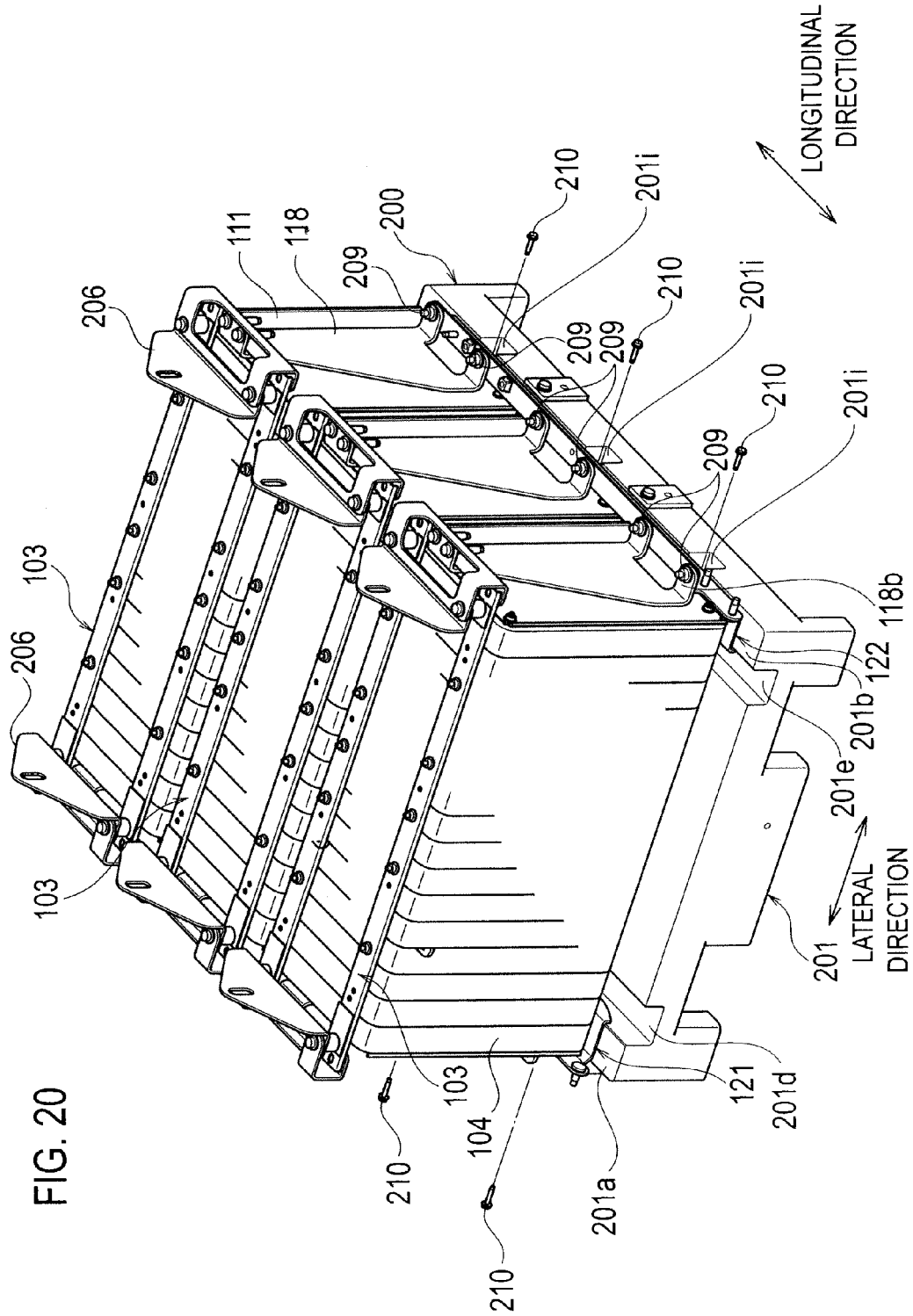
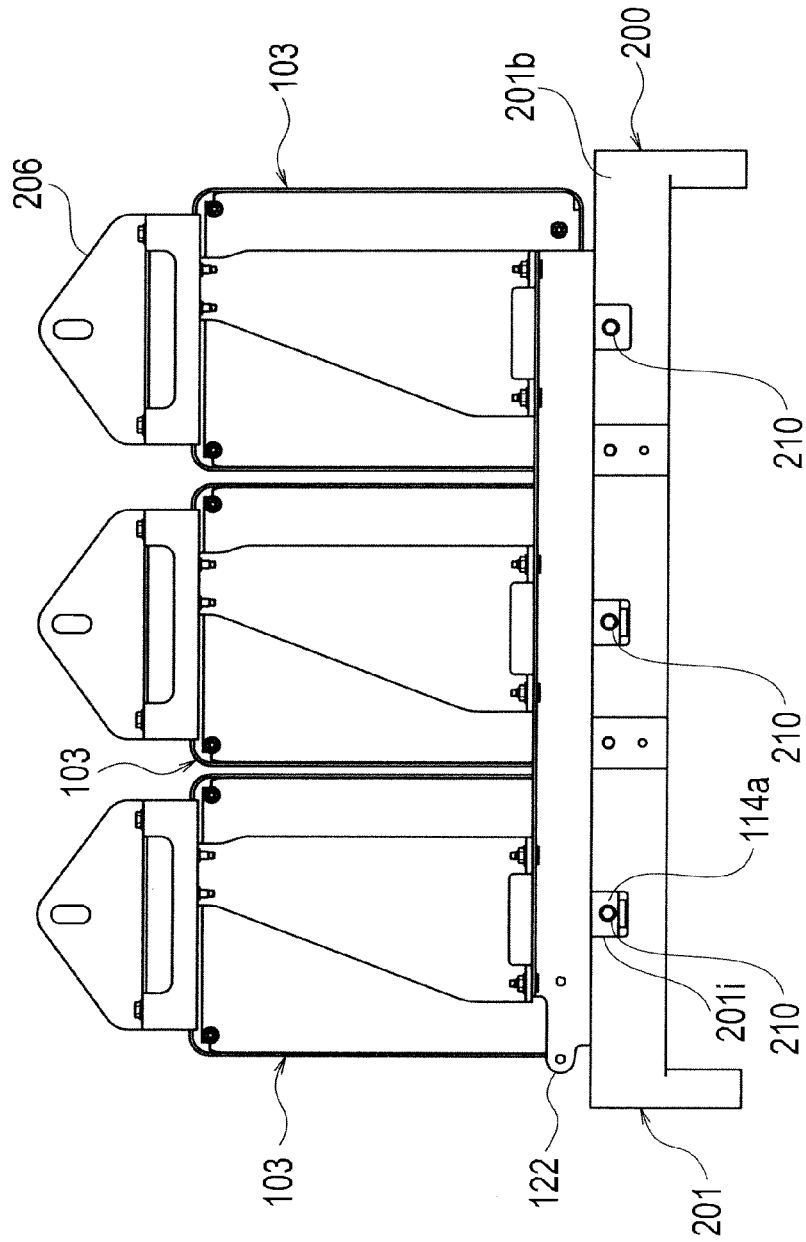


FIG. 21



**BATTERY PACK****CROSS-REFERENCE TO RELATED PATENT APPLICATIONS**

This application is a divisional application of U.S. application Ser. No. 13/265,453 filed Oct. 20, 2011, which is the National Stage Application of International Application No. PCT/JP2010/057216, filed Apr. 23, 2010, which claims priority to Japanese Patent Application Nos. 2009-106856 and 2009-106895 filed Apr. 24, 2009, the entire contents of all are incorporated herein by reference.

**TECHNICAL FIELD**

The present invention relates to a battery pack.

**BACKGROUND ART**

Patent Literature 1, for example, has disclosed a technology of forming a battery pack by: forming a battery module by arranging multiple batteries; and arranging such battery modules. Particularly, such a battery pack is installed in electric cars for use as drive sources for their motors.

**CITATION LIST****Patent Literature**

Patent Literature 1: Japanese Patent Unexamined Publication No. 2007-165164

**SUMMARY OF THE INVENTION**

However, the conventional battery pack has a problem that the overall volume of the battery pack becomes large if a side from which various brackets and the like protrude is different from a side on which accessories such as a battery controller are disposed.

An object of the present invention is to provide a battery pack reduced in overall volume.

A battery pack of the present invention is characterized by including: paired supporting members disposed with a predetermined interval in between; a battery module disposed between the supporting members; and a stack member supporting the battery module by linking the supporting members to each other, and characterized in that: an extending portion protruding from the battery module is formed by extending an end portion of the stack member in an extending direction of the stack member; the supporting member and the extending portion of the stack member are connected to each other by a supporting bracket; and accessories are attached to at least a side surface on a side where the extending portion of the stack member is disposed, the side surface being one of side surfaces of the battery pack which are provided with the paired supporting members. Note that the battery module of the present invention is not limited to one formed from multiple batteries, but includes one formed of a single battery.

**BRIEF DESCRIPTION OF DRAWINGS**

FIG. 1 is a perspective view showing a battery pack of a first embodiment of the present invention.

FIG. 2 is a perspective view showing a process of assembling the battery pack of the first embodiment of the present invention.

FIG. 3 is a perspective view showing the battery pack of the first embodiment of the present invention which is an assembled end product.

FIG. 4 is a plan view of the battery pack of FIG. 1 which is viewed from above.

FIG. 5 is perspective view showing a battery pack of a second embodiment of the present invention.

FIG. 6 is a perspective view showing a battery module of the second embodiment of the present invention.

FIG. 7 is a front view showing the battery module of the second embodiment of the present invention.

FIG. 8 is a plan view showing the battery module of the second embodiment of the present invention.

FIG. 9 is a side view showing the battery module of the second embodiment of the present invention.

FIG. 10 is an exploded perspective view showing the battery module of the second embodiment of the present invention.

FIG. 11 is an exploded perspective view showing a battery, and first and second connection members of the second embodiment of the present invention.

FIG. 12 is an exploded perspective view showing the battery and spacers of the second embodiment of the present invention.

FIG. 13 shows a first pillar member of the second embodiment of the present invention. FIG. 13(a) is a side view thereof, FIG. 13(b) is a front view thereof, and FIGS. 13(c) and 13(d) are side views of pin members.

FIG. 14 shows a second pillar member of the second embodiment of the present invention. FIG. 14(a) is a side view thereof, and FIG. 14(b) is a front view thereof.

FIG. 15 is a view showing a process of manufacturing the battery pack of the second embodiment of the present invention.

FIG. 16 is another view showing a process of manufacturing the battery pack of the second embodiment of the present invention.

FIG. 17 is another view showing a process of manufacturing the battery pack of the second embodiment of the present invention.

FIG. 18 is another view showing a process of manufacturing the battery pack of the second embodiment of the present invention.

FIG. 19 is yet another view showing a process of manufacturing the battery pack of the second embodiment of the present invention.

FIG. 20 is still another view showing a process of manufacturing the battery pack of the second embodiment of the present invention.

FIG. 21 is the other view showing a process of manufacturing the battery pack of the second embodiment of the present invention.

**DESCRIPTION OF EMBODIMENTS**

Embodiments of the present invention will be described below in detail together with the drawings. Note that descriptions will be given of a first embodiment and a second embodiment as a battery pack to be installed in an electric car being an example of a vehicle. However, the battery pack can be installed in other vehicles such as a hybrid car including a motor and an engine. Moreover, descriptions are given below of a battery pack in which battery modules each obtained by arranging multiple batteries in a thickness direction of the batteries are vertically stacked. However, the present inven-

3

tion can be applied to a battery pack in which individual batteries are vertically stacked.

#### First Embodiment

FIG. 1 is a perspective view showing a battery pack of a first embodiment of the present invention.

A battery pack 1 of the embodiment includes: three battery modules 3, 5, 7 stacked vertically; and accessories 12 attached to side portions of the respective battery modules 3, 5, 7. The battery pack 1 in an on-vehicle state is disposed in a way that a vehicle front side, a vehicle rear side, and a vehicle width direction are as shown by their respective arrows in FIG. 1. Three battery modules include: the upper battery module 3 disposed in the uppermost tier; a center battery module 5 disposed in the middle in a height direction; and the lower battery module 7 disposed in the lowermost tier. These battery modules 3, 5, 7 are connected to each other by elongated supporting plates 11 extending in a vertical direction and supporting brackets 51, which will be described later. Moreover, in each of the battery modules 3, 5, 7, multiple plate-shaped batteries 9 are arranged in parallel in the vehicle width direction (in the thickness direction of the batteries 9), and are connected to each other. Furthermore, the aforementioned accessories 12 include, specifically, a battery controller (for example, a lithium-ion battery controller) 13, wire harnesses 14, an attachment plate 16 to which to attach the battery controller 13, and the like.

FIG. 2 is a perspective view showing a process of assembling the battery pack.

The supporting plates 11 are fastened by bolts to a pallet jig 31 placed on a floor surface. End plates 36 being parts of supporting members 35 are fastened to the supporting plates 11 by bolts. Each supporting member 35 is formed from a corresponding one of the end plates 36 and reinforcement member 37. Specifically, the reinforcement members 37 are joined to the end plate 36. Moreover, bent portions 37b, 37c bent and extending in a lateral direction (a substantially horizontal direction) are provided to the lower end of each reinforcement member 37, and a bent portion 37a bent and extending in the lateral direction (the substantially horizontal direction) is provided to the upper end of the reinforcement member 37. The bent portions 37b, 37c are fastened to a corresponding one of the supporting plates 11 by bolts.

Furthermore, both end portions of each of stack members 43 in a longitudinal direction are extended to form extending portions 43a which overhang (protrude) from the battery modules 3, 5, 7. The stack members 43 support the battery modules 3, 5, 7 by use of bolts 45 and connecting members, which are not illustrated.

The paired supporting members 35 formed from the end plate 36 and the reinforcement members 37 are provided, respectively, on the two endmost side surfaces of the battery module 3 in the vehicle width direction. The accessories 12 (see FIG. 1) are provided on at least a side surface situated on a side where the extending portions 43a of the stack members 43 are disposed, which is one of the side surfaces on which the supporting members 35 are disposed. In the embodiment, the supporting members 35 are provided respectively on both sides in the vehicle width direction, and the extending portions 43a of the stack members 43 are provided on both sides. Thus, the attachment plate 16, the battery controller 13, and the wire harnesses 14 connected to the battery controller 13, which constitute the accessories 12, are disposed on the side surfaces of both supporting members 35, 35.

Note that each of the battery modules 3, 5, 7 is formed by arranging the plate-shaped batteries 9 side by side in the

4

thickness direction. Multiple terminals (not shown) are provided on the upper surfaces of the batteries 9. Moreover, as shown in FIG. 2, each of the supporting brackets 51 is integrally formed from an upper surface 51a and a side surface 51b formed by being bent in a direction orthogonal to the upper surface 51a, and has an almost L-shape in a side view.

In addition, as shown in FIG. 2, the supporting brackets 51 are attached, from below, to the extending portions 43a of the stack members 43 and the bent portions 37a of the reinforcement members 37. A corner portion, which is shaped almost like the letter L in the side view, is formed, in an upper end portion of the side surface of each supporting member 35, by the extending portions 43a of the corresponding stack member 43 and the bent portion 37a of the corresponding reinforcement member 37. The upper surfaces 51a of the supporting brackets 51 are pressed against the lower sides of the extending portions 43a and the lower sides of the bent portions 37a, and the supporting brackets 51 are fastened to the extending portions 43a and the bent portions 37a by screwing bolts from above. Thus, as shown in FIG. 3, the supporting brackets 51 are attached, from below, to the extending portions 43a of the stack members 43 and the bent portions 37a of the reinforcement members 37 with the supporting brackets 51 matched to the upper end corner portions of the supporting members 35.

FIG. 4 is a plan view showing the battery pack shown in FIG. 1, which is viewed from above.

As shown in FIG. 4, a length L1 by which the extending portion 43a of the stack member 43 protrudes from the upper battery module 3 is set larger than a length L2 by which the battery controller 13 being one of the accessories 12 protrudes from the upper battery module 3.

Specifically, L1 is defined as a length of the extending portion 43a in the extending direction, between an edge 3a of the upper battery module 3 which extends in the thickness direction of the batteries 9 (in an extending direction of the extending portion 43a) and an edge 43b of the extending portion 43a of the stack member 43. Moreover, L2 is defined as a length in the extending direction of the extending portion 43a between the edge 3a of the upper battery module 3 which extends in the thickness direction of the batteries 9 and a side surface 13a of the battery controller 13. In this respect, L1 and L2 are set to satisfy a relationship of  $L1 > L2$ . Note that the protruding length of each wire harnesses 14, which is not illustrated, is also set smaller than L1.

Operations and effects of the first embodiment will be described below.

(1) The battery pack 1 of the embodiment includes: the paired supporting members 35, 35 disposed with a predetermined interval in between; the battery modules 3, 5, 7 disposed between the supporting members 35, 35; and the stack members 43 linking the supporting members 35, 35, and supporting the battery modules 3, 5, 7. Moreover, the extending portions 43a protruding from the battery modules 3, 5, 7 are formed by extending the end portions of the stack members 43 in the extending direction of the stack members 43. The accessories 12 are attached to at least a side surface on which the extending portions 43a of the stack members 43 are disposed, which is one of the side surfaces on which the respective paired supporting members 35, 35 are provided.

Since the accessories 12 are attached to the side surfaces of the supporting members 35 disposed on the sides provided with the extending portions 43a of the stack members 43 as described above, the overall volume of the battery pack 1 can be reduced.

In other words, if the accessories 12 are disposed on a side surface which is not on the sides on which the extending

5

portions **43a** of the stack members **43** are disposed, the volume is increased by the extending portions **43a** on the side on which the extending portions **43a** are disposed and the volume is increased by the accessories **12** on the side provided with the accessories **12**. Thus, disposing the accessories **12** on the side surfaces on the sides on which the extending portions **43a** are disposed allows the overall volume of the battery pack **1** to be reduced.

(2) The protruding length **L1** of the extending portions **43a** of the stack members **43** from the battery modules **3**, **5**, **7** is set to be larger than the protruding length **L2** of the accessories **12** from the battery modules **3**, **5**, **7**.

Thus, when an impact load in the vehicle width direction is applied to the battery pack **1**, the extending portions **43a** of the stack members **43** can protect the accessories **12**.

(3) In the battery pack **1** of the embodiment, the bent portions **37a** are formed by laterally bending the upper ends of the reinforcement members **37** joined to the end plates **36**, and the extending portions **43a** overhanging from the end portions of the battery modules **3**, **5**, **7** are formed by extending the end portions of the stack members **43**. Then, the supporting brackets **51** each having an almost L-shaped cross section are attached, from below, to the bent portions **37a** of the reinforcement members **37** and the extending portions **43a** of the stack members **43**.

As described above, the bent portions **37a** of the reinforcement members **37** and the extending portions **43a** of the stack members **43** do not protrude toward the terminals of the batteries **9**. Thus, wires are easily connected to the terminals, and the entire battery pack **1** can be made compact. Moreover, the accessories **12** can be attached to the side surface of the battery pack **1** which is provided with reinforcement members **37**, and the side surface is effectively used.

#### Second Embodiment

The second embodiment of the present invention will be described by referring to the drawings. In the drawings, FR indicates frontward in a vehicle frontward-rearward direction, and UP indicates upward in a vehicle upward-downward direction.

A battery pack **102** of the embodiment is installed in an electric car, and supplies electricity to a driving motor of the electric car. Note that the battery pack **102** of the embodiment can be installed in other vehicle such as a hybrid car including a motor and an engine.

As shown in FIG. 5, the battery pack **102** installed in an electric car (not shown) includes multiple battery modules **103** vertically stacked, and a controller (not shown).

The battery pack of the embodiment includes three battery modules **103**, and these battery modules **103** are connected together in series, for example, by use of connection members, which are not illustrated. As shown in FIGS. 6 to 10, each of the battery modules **103** includes: multiple batteries **104** arranged in a row and; a frame **105** holding the multiple batteries **104**. The batteries **104** are connected together in series by use of connection members, which are not illustrated.

As shown in FIGS. 11 and 12, each of the batteries **104** is formed in a rectangular plate shape, and insertion holes **104a** are formed in the respective four corners of the battery **104** in a manner that makes the insertion holes **104a** penetrate the battery **104** in a plate-thickness direction. The battery **104** is a secondary battery such as a lithium ion secondary battery, a nickel hydrogen secondary battery, or a nickel cadmium secondary battery. The multiple batteries **104** are arranged side by side in a row (in the thickness direction of the batteries

6

**104**). First connection members **107** serving as connection members, second connection members **108** serving as connection members, and spacers **109** are provided between the batteries **104**.

One of the first connection members **107** and one of the second connection members **108** are disposed together between each adjacent two of the batteries **104**. In other words, the multiple first connection members **107** are arranged in the direction of the row of the batteries **104** with intervals in between, and the multiple second connection members **108** are arranged in the direction of the row of the batteries **104** with intervals in between.

As shown in FIG. 11, the first connection member **107** includes: a plate portion **107a** to be interposed between each two adjacent batteries **104**; paired cylinder portions **107b** penetrating the plate portion **107a**; paired attachment portions **107c** formed by being bent from the plate portion **107a**; and bolt portions **107d** fixed to the respective attachment portions **107c**. The first connection member **107** is disposed between each two adjacent batteries **104** with end portions of the cylinder portions **107b** fitted into the insertion holes **104a** of the battery **104** on the front side, and with the plate portion **107a** interposed between the adjacent batteries **104**. Meanwhile, the second connection member **108** includes: a plate portion **108a** to be interposed between each two adjacent batteries **104**; paired cylinder portions **108b** penetrating the plate portion **108a**; an attachment portion **108c** formed by being bent from the plate portion **108a**; and a bolt portion **108d** fixed to the attachment portion **108c**. The second connection member **108** is disposed between each two adjacent batteries **104** with end portions of the cylinder portions **108b** fitted into the insertion holes **104a** of the battery **104** on the rear side, and with the plate portion **108a** interposed between the adjacent batteries **104**. Thus, the first connection member **107** and the second connection member **108** thus disposed between each two adjacent batteries **104** cause the adjacent batteries **104** to be positioned to each other, and form a gap between the adjacent batteries **104**.

The spacers **109** are disposed in a space between the each two adjacent batteries **104** in which neither the first connection member **107** nor the second connection member **108** is disposed. Each of the spacers **109** includes a cylinder portion **109a**, and a flange portion **109b** provided on the circumferential surface of the cylinder portion **109a**. The spacers **109** are disposed between each two adjacent batteries **104**, matching the insertion holes **104a** of the batteries **104**. Each spacer **109** is disposed between each two adjacent batteries **104** with the end portion of the cylinder portion **109a** fitted into the corresponding insertion hole **104a** of the battery **104**, and with the flange portion **109b** interposed between the adjacent batteries **104**. The spacers **109** thus disposed cause the adjacent batteries **104** to be positioned to each other, and form a gap between the adjacent batteries **104**. Moreover, different spacers **110** are disposed between each endmost battery **104** and its corresponding end plate **111**.

As shown in FIGS. 6 to 10, the frame **105** includes: paired end plates **111** sandwiching the stacked multiple batteries **104**; multiple through-bolts **112** inserted in the end plates **111** and the multiple batteries **104** in the direction of the row of the batteries **104**; stack members **43** situated on the outer side of the batteries **104**, and extending in the direction of the row of the batteries **104**; and a stack plate **114**.

The through-bolts **112** are provided, matching the respective insertion holes **104a** of each battery **104**. The two through-bolts **112** on the rear side are respectively inserted in the cylinder portions **107b** of the first connection members **107** and the cylinder portions **109a** of the spacers **109** as well.

Meanwhile, the two through-bolts on the front side are inserted in the cylinder portions **108b** of the second connection member **108** and the cylinder portions **109a** of the spacers **109** as well. Then, nuts **115** are screwed to the through-bolts **102**, respectively. Thus, the through-bolts **112** support the multiple batteries **104**, and the paired end plates **111** hold the multiple batteries **104** between the end plates **111**. While in this state, the two through bolts **112** on the rear side are connected to the first connection members **107**, and the two through bolts **112** on the front side are connected to the second connection members **108**.

As shown in FIG. 7, each of the stack members **43** is formed in a band plate-like shape, and is provided on the rear side of the battery module **103**. An extending portion **43a** is formed in each of the two end portions of the stack member **43**. Moreover, multiple first insertion holes (not shown) are formed in the stack members **43**, matching the first connection members **107**, respectively. The bolt portions **107d** of the first connection members **107** are inserted in the first insertion holes, and nuts **116** are screwed to the bolt portions **107d**, respectively. Thus, the first connection members **107** are fixed to the stack members **43**. In other words, the first connection members **107** link together the stack member **43** and the through-bolts **112** on the front side. Note that a center line CL in FIG. 7 indicates a center position of the battery module **103** in the direction of the row (longitudinal direction).

As shown in FIGS. 8 and 9, the stack plate **114** is formed in a band plate-like shape, and is provided on the front side of the battery module **103**. An attachment portion **114a** is formed in each of the two end portions of the stack plate **114** by bending. An insertion hole **114b** is formed in the attachment portion **114a**, penetrating the attachment portion **114a** in the direction of the row of the batteries **104**. A nut **114c** is fixed to the attachment portion **114a**. The nut **114c** communicates with the insertion hole **114b**. Moreover, multiple second insertion holes (not shown) are formed in the stack plate **114**, matching the second connection members **108**, respectively. The bolt portions **108d** of the second connection members **108** are inserted in the second insertion holes, and nuts **117** are screwed to the bolt portions **108d**, respectively. Thus, the second connection members **108** are fixed to the stack plate **114**. In other words, the second connection members **108** link the stack plate **114** and the through-bolts **112** on the front side to each other.

As shown in FIGS. 6 and 9, a reinforcement plate **118** is fixed to each of the end plates **111**. A first attachment portion **118a** is formed in a stack member **43**-side end portion of the reinforcement plate **118** by bending, and paired second attachment portions **118b** are formed in a stack plate **114**-side end portion of the reinforcement plate **118** by bending. An engagement hole **118c** serving as a first engaging portion is formed in each of the second attachment portions **118b**.

In the battery module **103** including the multiple batteries **104** and the frame **105**, an interval between the connection members (the first connection members **107** and the second connection members **108**) adjacent to each other in the direction of the row of the batteries **104** becomes smaller from the ends toward the center in the direction of the row of the batteries **104** of the battery module **103**.

Each of the battery modules **103** is supported at both end portions **103b** in the direction of the row of the batteries **104**. Moreover, each of the stack members **43**, the stack plate **114**, and the through-bolts **112** are supported at both ends thereof. In this state, a space is provided between each two battery modules **103** vertically adjacent to each other, and a space is

provided below the lowermost battery module **103**. The batteries **104** are designed to be cooled by the air flowing through these spaces.

A main frame, which is not illustrated, includes first and second pillar members **121**, **122** being paired pillar members provided in a manner that makes the first and second pillar members **121**, **122** correspond to the respective end portions of the battery module **103** in the direction of the row, and the like, as well as is configured to be fixed to a vehicle body. The first and second pillar members **121**, **122** each support the corresponding end portion of the battery module **103**.

As shown in FIGS. 13(a) and 13(b), the first pillar member **121** includes: a pillar main body **123** formed of a plate member; and multiple pin members **124** fixed to the pillar main body **123**, and serving as second engagement portions.

As shown in FIG. 13(c), a tapered portion **124a** having a circular truncated cone shape whose diameter becomes smaller toward the tip is formed in an end portion of each of the pin members **124**. The tapered portion **124a** is inserted in and is thus engaged with the corresponding one of the engagement holes **118c** of the reinforcement members **118**. The pin member **124** is specifically a screw. Note that the tapered portion **124a** may be formed integrally with the pin member **124**, as shown in FIG. 13(c). Alternatively, like a pin member **224** shown in FIG. 13(d), a separate tapered cap **224a** may be fitted to an end of the pin member **224**.

The pillar main body **123** is formed of: a first flat plate portion **123a**; a second flat plate portion **123b** formed by being bent from a side edge of the first flat plate portion **123a**; a third flat plate portion **123c** formed by being bent from a side edge of the second flat plate portion **123b**; and a fourth flat plate portion **123d** formed by being bent from the third flat plate portion **123c**. Accordingly, the pillar main body **123** has an almost W-shaped cross section.

In the first flat plate portion **123a**, the pin members **124** are arranged with an interval between each two adjacent pin members **124** in the longitudinal direction of the first pillar member **121**. Moreover, a pin member **126** different from the pin members **124** is also fixed to the first flat plate portion **123a**.

In the fourth flat plate portion **123d**, insertion holes **123e** are formed with an interval between each two adjacent insertion holes **123e** in the longitudinal direction of the pillar member **121**, and insertion holes **123f** are formed with an interval between the insertion holes **123f** in the longitudinal direction of the pillar member **121**. Each of the insertion holes **123f** is positioned between the corresponding two adjacent insertion holes **123e**, and one of the insertion holes **123f** is provided with a nut **125**. The nut **125** is fixed to the fourth flat plate portion **123d** by welding or the like, and communicates with the one insertion hole **123f**.

The second pillar member **122** is basically the same as the first pillar member **121**, and is formed to be right-left symmetrical with respect to the first pillar member.

As shown in FIGS. 14(a) and 14(b), the second pillar member **122** includes: a pillar main body **128** formed of a plate member; and multiple pin members **129** fixed to the pillar main body **128**, and serving as the second engagement portions.

A tapered portion **129a** whose diameter becomes smaller toward the tip is formed in an end portion of each of the pin members **129**, as in the case of the pin members **124**. The tapered portion **129a** is engaged with the corresponding one of the engagement holes **118c** of the reinforcement members **118** by being inserted in the engagement hole **118c**. The pin member **129** is a screw. Note that the tapered portion **129a** may be formed integrally with the pin member **129**. Alterna-

tively, like the pin member described using FIG. 13, a separate tapered cap (not shown) may be fitted to an end of a pin member.

The pillar main body **128** is formed of: a first flat plate portion **128a**; a second flat plate portion **128b** formed by being bent from a side edge of the first flat plate portion **128a**; a third flat plate portion **128c** formed by being bent from a side edge of the second flat plate portion **128b**; and a fourth flat plate portion **128d** formed by being bent from the third flat plate portion **128c**, as well as has an almost W-shaped cross section.

In the first flat plate portion **128a**, the pin members **129** are arranged with an interval between each two adjacent pin members **129** in the longitudinal direction of the second pillar member **122**. Moreover, a pin member **130** different from the pin members **129** is also fixed to the first flat plate portion **128a**.

In the fourth flat plate portion **128d**, insertion holes **128e** are formed with an interval between each two adjacent insertion holes **128e** in the longitudinal direction of the pillar member **122**, and insertion holes **128f** are formed with an interval between the insertion holes **128f** in the longitudinal direction of the pillar member **122**. Each of the insertion holes **128f** are positioned between the corresponding two adjacent insertion holes **128e**. The second pillar member **122** is not provided with a nut which corresponds to the nut **125** of the first pillar member **121**.

Next, descriptions are given of a method of positioning the battery modules and a method of manufacturing the battery pack. The method of positioning the battery modules is a method of positioning the battery modules **103** and the first and second pillar members **121**, **122** relative to one another, the battery modules **103** each including the multiple batteries **104** in a row, the first and second pillar members **121**, **122** being the paired pillar members for supporting the end portions of the battery modules **103** in the direction of the row. The battery modules **103** and the first and second pillar members **121**, **122** are designed to be capable of being positioned using a jig apparatus **200** shown in FIG. 15.

The jig apparatus **200** includes: a pallet **201**; and bolts **204**, **205** being turn prevention members for preventing the turn of pillar members **121**, **122**. Note that in the descriptions below, the lateral direction (right-left direction) and the longitudinal direction of the pallet **201** will be simply referred to as the lateral direction and the longitudinal direction, respectively.

The pallet **201** includes: a base portion **201g** shaped like a rectangular plate; and leg portions **201p** formed integrally with the respective lower portions of the base portion **201g**.

In the upper surface of the base portion **201g**, paired supporting portions **201a**, **201b** extending in the longitudinal direction are formed respectively in both edge portions in the lateral direction, and a block portion **201c** is formed between the paired supporting portions **201a**, **201b**. In the base portion **201g**, paired groove portions **201d**, **201e** are formed respectively in a portion between the supporting portion **201a** and the block portion **201c**, and in a portion between the supporting portion **201b** and the block portion **201c**. The groove portions **201d**, **201e** extend in the longitudinal direction, and are formed with an interval in between in the lateral direction.

Multiple lateral groove portions **201f** extending in the lateral direction are formed in the supporting portion **201a**. Multiple lateral groove portions **201i** extending in the lateral direction are formed in the supporting portion **201b**. The lateral groove portions **201f** are formed with an interval between each two adjacent lateral groove portions **201f** in the longitudinal direction, and the lateral groove portions **201i** are formed with an interval between each two adjacent lateral

groove portions **201i** in the longitudinal direction. Moreover, multiple insertion holes **201h** are formed in the supporting portion **201a**, and multiple insertion holes **201k**, **201j** are formed in the supporting portion **201b**. The insertion holes **201h** are formed with an interval in between in the longitudinal direction, and the insertion holes **201k**, **201j** are formed with an interval in between in the longitudinal direction. The insertion holes **201h** penetrate the supporting portion **201a** in the lateral direction, and the insertion holes **201k**, **201j** penetrate the supporting portion **201b** in the lateral direction. The corresponding one of the bolts **204**, **205** is inserted into each of the insertion holes **201h**, **201k**, **201j**. In addition, reinforcement plates **201m** are provided on the outer surface of each of the supporting portions **201a**, **201b**, and the insertion holes **201h**, **201k**, **201j** are formed, respectively penetrating the reinforcement plates **201m** as well. An upper surface **201r** of the right supporting portion **201b** functions as a slide support portion for slidably supporting the second pillar member **122** in a way that enables the adjustment of an interval between the first and second pillar members **121**, **122** in the direction of the row of the batteries **104**, and the adjustment of relative positions of the respective first and second pillar members **121**, **122** in the direction orthogonal to the direction of the row of the batteries **104**.

Screw holes **201n** are formed in both side portions of the block portion **201c**, situated coaxial with the respective insertion holes **201h**, **201k**, **201j** which are formed in the supporting portion **201a**, **201b**. The screw holes **201n** are formed, extending in the lateral direction.

In the method of manufacturing the battery pack, the battery modules **103** are mounted on the pallet **201** with the first and second pillar members **121**, **122** in between in such a way that: the direction of the row of the batteries **104** coincides with the lateral direction of the pallet **201**; and the direction orthogonal to the direction of the row of the batteries **104** coincides with the longitudinal direction of the pallet **201**.

In the method of manufacturing the battery pack, firstly, as shown in FIG. 16, the first and second pillar members **121**, **122** are assembled to the jig apparatus **200** (a pillar members assembling step).

To be more specific, the first pillar member **121** is mounted on the one (left) supporting portion **201a**, and the second pillar member **122** is mounted on the other (right) supporting portion **201b**. At this time, the third flat plate portions **123c**, **128c** of the first and second pillar members **121**, **122** are mounted on upper surfaces **201g**, **201r** of the supporting portions **201a**, **201b**, respectively; and the fourth flat plate portions **123d**, **128d** of the first and second pillar members **121**, **122** are brought into contact with inner surfaces **201s** (an inner surface of the supporting portion **201b** is not shown) of the supporting portions **201a**, **201b**, respectively.

Then, the bolt **204** is inserted in the insertion hole **201h** of the one (left) supporting portion **201a** on a far side and in the insertion hole **123f** of the first pillar member **121** on the far side. Subsequently, the bolt **204** is screwed to the nut **125**. Subsequently, the bolt **205** is inserted in the insertion hole **201h** of the supporting portion **201a** on a near side and in the insertion hole **123f** of the first pillar member **121** on the near side. Thereafter, the bolt **205** is screwed to the corresponding screw hole **201n**. Thus, the first pillar member **121** is fixed to the pallet **201**.

After that, the bolt **205** is inserted in the insertion hole **201j** of the other (right) supporting portion **201b** on the far side and in the insertion hole **128f** of the second pillar member **122** on the far side. Subsequently, the bolt **205** is screwed to the corresponding screw hole **201n**. Concurrently, the bolt **205** is inserted in the insertion hole **201k** of the supporting portion

11

201b on the near side and in the insertion hole 128f of the second pillar member 122 on the near side. Thereafter, the bolt 205 is screwed to the corresponding screw hole 201n. While in this state, the second pillar member 122 is supported by the upper surface 201r of the supporting portion 201b, movable in the longitudinal direction and the lateral direction. To be more specific, the second pillar member 122 is movable in a direction toward the first pillar member 121, which is the lateral direction. Thus, the second pillar member 122 is slidably supported by the upper surface 201r of the supporting portion 201b in a way that enables the adjustment of the interval between the first and second pillar members 121, 122 in the lateral direction (the direction of the row of the batteries 104), and the adjustment of the relative positions of the respective first and second pillar members 121, 122 in the longitudinal direction (the direction orthogonal to the direction of the row of the batteries 104) are adjustable. In this configuration, the diameter of each of the insertion holes 123f, 128f of the first and second pillar members 121, 122 is formed, larger than the diameter of a shaft portion of the bolts 205, and there is a backlash between each of the insertion holes 123f, 128f and their corresponding bolts 205. Accordingly, the insertion holes 128f allow the second pillar member 122 to move in the lateral direction (the direction of the row of the batteries 104) and in the longitudinal direction (the direction orthogonal to the direction of the row of the batteries 104), with the bolts 205 being inserted. Moreover, while in this state, the turn of the first pillar member 121, specifically the turn thereof about an imaginary axis extending in the longitudinal direction, is prevented by the bolts 204, 205. In addition, the turn of the second pillar member 122, specifically the turn thereof about an imaginary axis extending in the longitudinal direction, is prevented by the bolts 205.

Next, as shown in FIG. 17, slingers 206 are fixed to the two respective end portions of the battery module 103 by bolts 207, 208.

Subsequently, as shown in FIG. 18, the slingers 206 are hooked to a crane (not shown), and the battery module 103 is moved to a position above the jig apparatus 200 by the crane. Then, as shown in FIGS. 19 and 20, the battery module 103 is lowered (moved) toward the first and second pillar members 121, 122 assembled to the jig apparatus 200. Thereafter, the pin members 124, 129 of the first and second pillar members 121, 122 are engaged with the insertion holes 118b of the battery module 103, and the first and second pillar members 121, 122 and the battery module 103 are positioned relative to one another (a relative positioning step). At this time, the tapered portions 129a of the pin members 129 are inserted into the insertion holes 118b while being in contact with the insertion holes 118b, and this causes the second pillar member 122 to be automatically positioned to the battery module 103.

After the positioning is completed in the foregoing manner, nuts 209 are screwed to the pin members 124, 129, respectively, and the battery module 103 is thereby fixed to the first and second pillar members 121, 122 (a fixing step). The remaining two battery modules 103 are positioned and fixed to the first and second pillar members 121, 122 by repeating the foregoing steps (see FIG. 20).

Next, a bolt 210 is screwed to each of the nuts 114c of the extending portions 43a of the second supporting member 113 of the battery modules 103, and thus the extending portions 43a are fixed to the first and second pillar members 121, 122 (see FIG. 21). At this time, the bolts 210 can be screwed to the nuts 114c by inserting the bolts 210 into the lateral groove portions 201f, 201i. Then, the slingers 206 are removed from the battery modules 103. Frame members other than the first

12

and second pillar members 121, 122, as well as a control device and the like are attached to the battery modules 103. Thus, the assembly of the battery pack 102 is completed. The battery pack 102 can be detached from the pallet 201 by removing the bolts 204, 205.

Next, operations and effects of the second embodiment will be described below.

(1) The embodiment enables the adjustment of the interval between the first and second pillar members 121, 122 in the direction of the row of the batteries 104, and the adjustment of the relative positions of the respective first and second pillar members 121, 122 in the direction orthogonal to the direction of the row. This makes it possible to easily absorb a dimension error of each battery module 103 in the direction of the row of the batteries 104.

(2) Moreover, in the present embodiment, the turn prevention members are the bolts 204, 205; and the second pillar member 122 being one of the pillar members has the insertion holes 128f which allow the movement of the pillar member 122 in the direction of the row of the batteries 104, and in the direction orthogonal to the direction of the row, with the bolts 205 being inserted. Accordingly, the relatively simple configuration makes it possible to prevent the turn of the second pillar member 122 while allowing the movement of the second pillar member 122.

(3) Furthermore, in the embodiment, engaged portions are the engagement holes 118c; and engaging portions are the pin members 124, 129 including the tapered portions 124a, 129a which are formed in a way that makes the tapered portions 124a, 129a each become smaller in diameter toward the tip portion. This enables the engagement holes 118c and the pin members 124, 129 to be engaged together smoothly.

It should be noted that the entireties of Japanese Patent Application No. 2009-106895 (whose filing date is Apr. 24, 2009) and Japanese Patent Application No. 2009-106856 (whose filing date is Apr. 24, 2009) are incorporated herein.

Moreover, the present invention is not limited to the embodiments describe above, and can employ other various embodiments within the scope not departing from the gist of the present invention.

For example, in the second embodiment, the slide support portion is not limited to the upper surface 201r of the other supporting portion 201b, and may be the upper surface 201q of the one supporting portion 201a. In this case, the screw hole 201n is provided instead of the nut 125. In this case, the upper surface 201q slidably supports the first pillar member 121 in a way that enables the adjustment of the interval between the first and second pillar members 121, 122 in the lateral direction (the direction of the row of the batteries 104), and the adjustment of the relative positions of the respective first and second pillar members 121, 122 in the longitudinal direction (the direction orthogonal to the direction of the row of the batteries 104). Furthermore, the slide support portion may be formed of the upper surfaces 201q, 201r of the two respective supporting portions 201a, 201b. In other words, it suffices if the slide support portion supports at least one of the paired pillar members in a way that enables the adjustment of the interval between the paired pillar members in the direction of the row in the battery module, and the adjustment of the relative positions of the respective paired pillar member in the direction orthogonal to the direction of the row.

Note that the present invention includes the following characteristics.

(1) The method of positioning the battery modules 103, in which the battery modules 103 each including the multiple batteries 104 arranged in a row and the paired pillar members 121, 122 supporting the end portions of the battery modules

## 13

**103** in the direction of the row are positioned relative to one another, the method including the steps of: assembling the paired pillar members **121**, **122** to the jig apparatus **200** enabling the adjustment of the interval between the paired pillar members **121**, **122** in the direction of the row and the adjustment of the relative positions of the respective paired pillar members **121**, **122** in the direction orthogonal to the direction of the row; positioning the pillar members **121**, **122** and the battery modules **103** relative to one another by: moving the paired pillar members **121**, **122**, which are assembled to the jig apparatus **200**, and the battery modules **103** relative to one another; engaging the engaged portions of the battery modules **103** and the engaging portions of the paired pillar members **121**, **122** together; and adjusting the interval between the pillar members **121**, **122** and the relative positions of the respective pillar members **121**, **122**.

(2) The method of positioning the battery modules, wherein: the jig apparatus **200** is provided with the bolts **204**, **205** serving as the members for preventing the turn of the pillar members; the pillar members have the insertion holes allowing the pillar members **121**, **122** to move in the direction of the row and in the direction orthogonal to the direction of the row, with the bolts **204**, **205** being inserted in the insertion holes; and the turn of the pillar members are prevented by the bolts **204**, **205** and the insertion holes.

(3) The method of positioning the battery modules, wherein: the engaged portions are the engagement holes; and the engaging portions are the pin members **129** each having the tapered portion which is formed in a way that makes the tapered portion become smaller in diameter toward a tip portion.

(4) The jig apparatus **200** for the battery pack **102** which includes: the pallet **201** including the slide support portion; and the bolts **204**, **205** serving as the turn prevention members, the jig apparatus **200** capable of positioning the battery modules **103** and the paired pillar members **121**, **122** in the battery pack **102** in which both end portions of the battery modules **103** in the direction of the row are supported by the paired pillar members **121**, **122**, the jig apparatus **200** wherein at least one of the paired pillar members **121**, **122** includes the insertion holes allowing the pillar members **121**, **122** to move in the direction of the row and in the direction orthogonal to the direction of the row, with the turn prevention members inserted in the insertion holes, as well as is slidably supported by the slide supporting portion in a way that enables the adjustment of the interval between the paired pillar members **121**, **122** in the direction of the row, and the adjustment of the relative positions of the respective paired pillar members **121**, **122** in the direction orthogonal to the direction of the row; and the turn is prevented by the turning prevention members.

## INDUSTRIAL APPLICABILITY

The present invention makes it possible to reduce the overall volume of the battery pack, because the accessories are attached to the side surfaces of the supporting members disposed on the sides where the extending portions of the stack members.

In other words, if the accessories would be disposed on a side surface on a side different from the sides where the extending portions of the stack members are disposed, the volume would be increased by the extending portions on the

## 14

side where the extending portions are disposed, while the volume would be increased by the accessories on the side where the accessories are provided. For this reason, disposing the accessories on the side surfaces on the sides where the extending portions are disposed makes it possible to reduce the overall volume of the battery pack.

## REFERENCE SIGNS LIST

- 1** BATTERY PACK
- 3** UPPER BATTERY MODULE (BATTERY MODULE)
- 5** CENTER BATTERY MODULE (BATTERY MODULE)
- 7** LOWER BATTERY MODULE (BATTERY MODULE)
- 9** BATTERY
- 12** ACCESSORIES
- 13** BATTERY CONTROLLER (ACCESSORY)
- 14** WIRE HARNESS (ACCESSORY)
- 16** ATTACHMENT PLATE (ACCESSORY)
- 35** SUPPORTING MEMBER
- 36** END PLATE (SUPPORTING MEMBER)
- 37** REINFORCEMENT MEMBER (SUPPORTING MEMBER)
- 43** STACK MEMBER
- 43a** EXTENDING PORTION
- 51** SUPPORTING BRACKET

The invention claimed is:

**1.** A battery pack comprising:

paired supporting members disposed with a predetermined interval in between;

a battery module disposed between the supporting members; and

a stack member supporting the battery module by linking the supporting members to each other, wherein

an extending portion protruding from the battery module is formed by extending an end portion of the stack member in an extending direction of the stack member, and the supporting members are connected to the extending portion of the stack member,

the supporting member includes a side surface constituting a corresponding one of side surfaces of the battery pack, and a bent portion bent at and extending from an end portion of the side surface, and

accessories are attached to at least a side surface on a side where the bent portion of the supporting member is disposed, among side surfaces of the battery pack which are provided with the paired supporting members.

**2.** The battery pack according to claim **1**, wherein the supporting members include end plates and reinforcement members, respectively,

the end plates are provided to two ends of the battery module, and the reinforcement members are connected to the end plates, respectively, and the

bent portion is provided to the reinforcement members.

**3.** The battery pack according to claim **1**, further comprising a support bracket configured to connect the support member and the extending portion of the stack member.

**4.** The battery pack according to claim **1**, wherein a length by which the extending portion of the stack member protrudes from the battery module is set larger than a length by which the accessories protrude from the battery module.

\* \* \* \* \*

UNITED STATES PATENT AND TRADEMARK OFFICE  
**CERTIFICATE OF CORRECTION**

PATENT NO. : 9,130,210 B2  
APPLICATION NO. : 14/077975  
DATED : September 8, 2015  
INVENTOR(S) : Hamada et al.

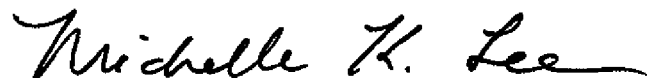
Page 1 of 1

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

On the Title page of the patent, the Related U.S. Application Data should read as follows:

- (62)** Division of application No. 13/265,453, filed as application  
No. PCT/JP2010/057216 on Apr. 23, 2010, now Pat. No. 8,592,068.

Signed and Sealed this  
Tenth Day of May, 2016



Michelle K. Lee  
*Director of the United States Patent and Trademark Office*